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BRIAN O'CONNELL

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ASPECTS OF LEARNING

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Aspects of Learning

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Introduction

For many students learning is associated with school and examinations, especially if they have recently sat for their GCE 'O' and 'A' levels. What they have learnt has been successfully or unsuccessfully recalled, remembered and reproduced. This ability to recall knowledge or remember facts, and the competence to reproduce them when required, form an important part of the learning process but by no means all of it. For the moment, however, let us ask a few pertinent questions concerned with this part of learning or acquisition of knowledge. Where has this knowledge been stored? Why is it that we remember some facts and forget others? What is happening to us when we are acquiring new skills or knowledge?

The answers to these and similar questions will be attempted in the following chapters. We would probably agree that for many people the learning process is not merely this ability to remember facts, statistics, symbols, statements or quotations and to apply these as required; nevertheless these are matters which must seriously concern the potential teacher. We are concerned with the development of learning in children, and from our own experience we will have noticed that some children learn more easily, and some more quickly than others. Very different views are expressed today concerning the methods of learning, but the validity or otherwise of these views of what takes place in school does not at the moment concern us. What is clear is the fact that children learn both in and out of school; they learn before they go to school and after they have left. Is all learning the same as that which takes place in school?

Let us first consider the different learning processes which occur in school. Are these in reality the same? We know that the content material is different in different classes, we know that the methods of teaching vary, but are similar mental processes being used by the various pupils? Take, for example, a second year of a secondary school comprising pupils mainly aged 12 to 13 years. They are divided up into six forms of mixed ability. The first form is writing an English composition – creative writing. They are, in fact, composing a piece of prose after listening to suitable music and viewing selected visuals on the subject of 'autumn'. What is it that these children have learnt?

Perhaps some physical facts about autumn or something about their own emotions; and almost certainly they will have used their previously learnt skill of writing.

Compare this class with the second group who are busily engaged in a mathematics lesson. They are attempting to solve problems which involve the use of quadratic equations. For some pupils this presents no difficulties since they quite easily apply the previously acquired rules and transfer this knowledge to the examples set. Others in the class appear bewildered and make random attempts by substituting the different numbers and symbols hoping that a correct solution will appear. This is a form of trial and error learning concerning which we have learned much from the American psychologist, Edward Thorndike (1874–1949), whose work we shall study later. Occasionally we may observe a highly delighted pupil who appears suddenly to have come upon the correct solution. How has this sudden insight come about? This insightful learning was thoroughly investigated by a group of German psychologists known as Gestaltists of whom the most famous was Wolfgang Köhler (1887–1967), and the value of whose work we shall consider later. In any class that we have observed we will have noticed that even children working at the same material appear to be learning by different methods.

Let us consider the children in another class, where they can be seen busily moving around, in and out of the classroom, in groups of two and three, each group armed with pads, pencils and work cards. On the latter are written a number of different questions all related to the Mediterranean climate and concerned with such topics as crops, soil, rainfall, temperature, buildings and clothes. The children are obtaining the answers to the questions on the cards from reference books, maps, pictures and other visual material displayed around the classroom and the school. This type of learning, using discovery methods, is based largely upon the work of the famous Swiss psychologist Jean Piaget.

In yet a fourth classroom a map of Western Europe, depicting the Battle of Waterloo is drawn on the blackboard. In front of the class the teacher is explaining how and why Napoleon was defeated, whilst the pupils are making notes and copying the map. This represents the didactic method, sometimes referred to as 'chalk and talk', which is under some criticism at the present time as being largely a type of rote learning, and sometimes even learning without a great deal of understanding.

In the fifth classroom the children, wearing head-phones, are seated at individual desks in a language laboratory working at their own speed through an oral lesson in French on 'travel'. The teacher is seated at the control panel able to listen to any individual child. Each pupil controls his own rate of progress by listening to the recording of his own work, comparing it with the correct version, making the necessary corrections and then proceeding to the next section. This type of programmed learning, as well as that of the pupils in our sixth and last class, is based to a large extent upon the work of another American psychologist, B. F. Skinner (b. 1904).

In this sixth class the pupils are seated at their own desks with a teaching machine programmed for a lesson in biology. By the appropriate selection of answers to questions posed, each child proceeds step by step through the course. If the wrong answer is selected then the machine leads the child through further steps until the right answer is obtained. In this way wrong answers are corrected, while children with the correct answers will immediately proceed to the next stage. This is known as linear programming.

All these different activities referred to above are going on at the same time with children of similar age. We presume that they are all learning, but is the process of learning as different as the method of teaching? Will some children learn more easily in one classroom than in another? Why are these different methods being employed? In this book we shall try and look at some of these questions, and we shall consider the rationale behind the wide selection of methods.

This broad spread of activity is still only a part of the process of learning. Consider, for example, the difference between a child in the infant school learning to read by the constant repetition of words and phrases such as, 'look', 'see', 'come Janet', 'come John', and a sixth-former in a comprehensive school completing a life-size model of a long-distance runner. There are numerous other comparisons which the reader can make for himself, and this wide variety of activities is all included under the process we call learning. But in reality these differing school activities are only a small part of the process of learning. As soon as a baby is born it begins to learn; before a child begins at school he has learnt to walk, to dress, to eat, to listen and to perform innumerable skills, of which the most important is the ability to communicate by using a language. These skills are often considered as 'social' learning and it is this type of learning which enables us to live in a community. The ability to speak and converse, however, is regarded not only as a social asset but also as an essential element in the development of thinking in its highest form, namely, that of abstract or logical thought. Many psychologists regard this not only as the major difference between human beings and other animals, but also as that factor which makes our learning processes so complex.

All students will have learnt some skills outside school. Most, for example, will be able to ride a bicycle; some will have learnt to drive a motor-car; some will be able to play musical instruments, and others will have achieved varying degrees of success on the playing fields. At first these tasks appeared to be difficult, but eventually they are performed without conscious thought. They are all, however, as much a part of the process we call learning as learning to read, to write or to calculate.

If we accept that these varieties of behaviour are part of the learning process, then it may perhaps be appreciated how difficult it is for psychologists to provide exact theories of learning to explain all the possible varieties. To complicate matters further man's learning is in some sense both 'social' and 'biological'. The result of our social learning is usually quite readily observed in changes in our overt behaviour; but what changes, if any, take place *within* us when we are learning? If there are biological changes, sometimes referred to as covert behaviour, it may be found necessary to study the working of the central nervous system; that is, the brain and the spinal cord, the part played by our senses, how the information received by them is conveyed to the brain where it is selected, encoded and the required action transmitted back through the central nervous system. There is also the latest theory of biochemical learning in which great advances have been made during recent years.

Because of the complexity of the subject-matter much of the study and research into this subject has been concentrated on the learning of animals. This has sometimes led to this field of study being called, somewhat unkindly, 'rat psychology'. It must be admitted, however, that the poor old white rat and other small animals have had to perform an amazing variety of activities under a wide range of experimental designs. As we study some of these experiments students may ask, 'What connection has this with children?' Before the answer can be directly given the student must appreciate that it is impossible to experiment with humans in the way that we do with animals. It must also be noted that, apart from obvious external physical differences, man is physiologically little different from other mammals lower in the phylogenetic scale. Also, of course, the experimenter is able to control the breeding of animals and their genetics; he is permitted to rear them in cages and laboratories and to control their environment. It is permissible (whatever our personal feelings) to remove sections of their brains and to apply noxious stimuli such as electric shocks as required by the experimental design. Finally, most animals used in experimental work have a comparatively short life-span compared with man, and this makes it possible to observe the various stages in development within one complete life-cycle which is so important when studying learning. One difficulty is that we cannot automatically transfer all the principles of animal learning to human learning, but sufficient evidence is available for us to make some valid comparisons and generalisations.

Although psychology is regarded by some as one of the biological sciences, so that any statement needs to be verified by observable and proven facts, it is also the science of behaviour. Learning, in fact, is often defined as a relatively more or less permanent change in behaviour which comes about as a result of practice. Behaviour itself is concerned with the human organism's interaction with its environment, both physical and social; so that, in a sense, the study of learning is actively concerned with the environment and its control.

As teachers we shall be concerned with the provision of the most suitable environment to facilitate learning. But unless we understand what is really meant by learning, and what takes place during learning, it becomes impossible for us to provide this. Learning is not just the acquisition of facts derived from a syllabus, but it is also concerned with interests, attitudes, the development of skills – both mental and physical, and the establishing of a system of values.

The following chapters attempt to examine the various theories of learning and something of their classroom application. We begin with simple learning usually known as classical conditioning, presented by the Russian psychologist, Ivan Pavlov. At all times some attempt will be made to provide relevant examples of classroom practice. Whilst this book will provide only a simple basis for study, the bibliographies will offer further reading in depth essential for any real understanding of the highly complex concept of learning.

Chapter 1

Simple Learning

I. P. PAVLOV (1849–1936)

Susan Kenny, aged 9 years, is seated in her classroom listening fairly attentively to her teacher reading R. L. Stevenson's poem, 'The Railway Carriage'. Her attention is momentarily distracted by Malcolm Weir who is engaged in drawing a railway engine on the lid of his desk. At this moment Miss Way, the teacher, who is feeling somewhat tired and irritable, asks Susan to explain the last line read. Unfortunately Susan is unable to do this and receives a rather severe reprimand and is singled out for constant reproof for the remainder of the poetry lesson. At the conclusion of the period Susan, usually a happy girl who enjoys most school activities, is heard to remark, 'Silly old thing, who wants to listen to soppy stuff like that?'

Being a good-natured child she soon recovers her composure and by the end of the afternoon has apparently forgotten the whole incident. Subsequently, however, she has similar experiences in the poetry lessons which she never really enjoys again either with Miss Way or with other teachers. We could say that Susan has been 'conditioned' to dislike poetry. The word 'conditioned' is frequently used today with rather sinister overtones often associated with political indoctrination.

The word 'indoctrination' is deliberately being introduced here since it will possibly cause some slight emotional discord in the reader. Why is this? Perhaps we associate indoctrination with some mysterious treatment which is meted out to political prisoners in different parts of the world. This may seem a long way from 9-year-old Susan Kenny and her poetry lesson. Susan, however, has undergone (in our example) a change of emotional response; and if we consider for a moment we shall probably discover that many of our own emotions are conditioned. Sometimes a certain tune, or a particular voice or picture will cause in us a momentary change in mood. We might find the reason for this too difficult to explain, and Susan Kenny would also probably find it problematic to explain in years to come why she never really enjoyed poetry. If you consider any such feelings which you may have about different school 'subjects', you may perhaps be able to explain why you liked history but hated English, or enjoyed chemistry but could never get on with physics.

But what has all this to do with simple learning? Susan Kenny has learnt to dislike poetry; she responds to it in a different way, and there has been a more or less permanent change in her behaviour which may be regarded as a form of learning. It is simple learning and is often associated with the emotional aspects of behaviour of which teachers and teachers in training should be very aware. Ivan Pavlov (1849–1936), the Russian psychologist, first introduced this concept known as classical conditioning in 1909 (1). He was primarily a physiologist and was interested in measuring the flow of saliva in dogs as part of his study of the digestive glands. When food is placed in the mouth of a dog saliva begins to flow, but Pavlov noticed that it also began to flow before the food was actually placed in the dog's mouth. In fact the dog would salivate at the mere appearance of the attendant bringing the food. This fact intrigued Pavlov and it is an indication of his brilliance that he decided to investigate the strange phenomenon instead of just dismissing it as a triviality.

He designed a basic experiment in which a dog was held in a loose harness set in a sound-proof room. The dog's parotid gland had previously been exposed on the outside of its cheek in order that the saliva could be collected and measured. By means of remote control Pavlov was able to introduce some meat powder into the animal's mouth. A metronome was set in motion and at almost the same time, or after a very short interval, the meat powder was introduced into the dog's mouth. The dog salivated and the amount of salivation was recorded. This process of pairing sound and food was repeated about twenty times. Finally the metronome was started on its own, the dog salivated without any presentation of food, and the salivation was measured.

A variety of alternatives were used for the metronome, such as a buzzer, a light or a bell, and similar results were achieved. This, then, was simple learning and the basis of the process was the establishment of an association between the *stimulus* (S) of the metronome and the *response* or *reflex* (R) of the salivation. The dog had learned to respond to the stimulus (S), the sound, with a response (R), the salivation, which was previously associated with the stimulus of the food. Pavlov called the salivation the *unconditioned reflex* (UR), while the meat powder was known as the *unconditioned stimulus* (US). The metronome was the *conditioned stimulus* (CS), and the salivation became the *conditioned reflex* (CR). This is represented by the diagram shown in Fig. 1.

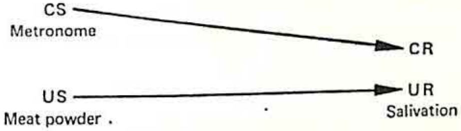

Figure 1

The word 'association' has purposely been used because Pavlov's work is often regarded as an objective demonstration of the idea of associationism which was first introduced by Aristotle as an explanation of learning. A simple example of this would be the fact that if you were to see one of your former teachers you would most likely be reminded of your old school, since in your previous experience the teacher and the school occurred together in place and time. The occurrence of these together is referred to as *contiguity*, an idea which was developed by a group of British philosophers known as the Empiricists during the seventeenth and eighteenth centuries. Prominent among these were John Locke, David Hume, John and James Mill and Herbert Spencer, who all considered that mental activity was nothing but the association of ideas. An idea included both the emotion experienced and the perception of the object.

Pavlov saw learning as an association between a stimulus (S) and a response (R) which had been paired together. Being essentially a physiologist he expressed his ideas in physiological terms, but his physiology appears somewhat suspect today in the light of modern research. He argued that all behaviour was the result of reflex actions to certain stimuli which could be either *external*, such as visual, aural and tactile, or *internal*, that is, changes in body metabolism due to hunger, thirst, fatigue and so on. These internal stimuli are called proprioceptive stimuli. Pavlov, to whom the central nervous system (the brain and the spinal cord) was a kind of telephone switchboard, believed that both the meat powder (US) and the metronome (CS) were represented as separate points in the cortex of the brain. After a time the excitation of the point corresponding to the CS would actuate the point corresponding to the US, and the salivation (CR) would occur. This explanation of the physiological processes in the brain has to some extent been superseded in recent years by a more sophisticated understanding of the central nervous system and the part played by the reticular activating system, the limbic system and the hypothalamus (see Chapter 5). Nevertheless Pavlov has provided a number of concepts vitally concerned with learning. As J. Deese and S. H. Hulse comment,

> 'This basic experiment of Pavlov's has had an enormous influence upon the psychology of learning, and the terms conditional and unconditioned stimuli and conditioned and unconditioned responses are part of the basic vocabulary of the psychology of learning' (2; p. 10).

Some of Pavlov's important findings were as follows:

1. *Extinction* In the basic experiment the CS (metronome) and the US (meat powder) are closely paired. If after conditioning has been achieved the CS is presented a number of times without the US, the CR (salivation) gradually becomes weaker and finally disappears completely.

2. *Spontaneous Recovery* If, however, after an appreciable delay the CS is presented again the CR reappears. A direct parallel might be that we often recall events that we had long forgotten when we unexpectedly meet someone we have not seen for years.

3. *Generalisation* After the CR has been established with the CS, and a new CS similar to the original CS is presented, the same CR occurs. For example, if the CS is the sound of a bell, a similar CR can be obtained by changing the tone, or if it is a light a similar CR can be obtained by varying the intensity of the light. Thus the CR generalises to the change of stimulus. The greater the similarity of the S the greater the response, the less similar the S the weaker the response. This has some important implications for education which will be referred to later on in the chapter entitled 'Transfer of Learning'.

4. *Discrimination* Again, it is possible to learn to discriminate between very similar stimuli and to respond to one and not to the other. Pavlov's dog learnt to respond to a circle but not to an ellipse, and also to discriminate between similar sounds of nearly equal volume. In everyday life we have to learn to discriminate between

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similar stimuli, otherwise we would be making a number of similar responses to different stimuli. For example, in school we learn to discriminate between the ringing of the school bell for the end of lessons and the ringing of the same bell as a fire warning; and when driving we quickly learn to discriminate between a green and red light.

Pavlov's work is only very briefly indicated here, but the interested reader will find a much fuller development of it in the books by E. R. Hilgard (3) and W. F. Hill (4). Although, as E. A. Lunzer (5; p. 9) says, 'Pavlov made no attempt to extend his conception of learning to allow of its implication to teaching', it might well be considered that the ability to generalise and to discriminate forms the basis of learning and education. A child learning to read is taught to generalise from 's-and' to 'l-and' and 'h-and', and also to discriminate between such words as 'there' and 'their'. When a child acquires the ability to classify, he generalises dogs, cats, horses, etc., as 'animals', and later he learns to discriminate between the different varieties of dogs. As teachers we must be careful to provide children with material containing sufficient common elements so that they may generalise, but we should not confuse them by providing material which is so similar that they experience difficulty in discriminating between common elements.

E. L. THORNDIKE (1874–1949)

Towards the end of the nineteenth century E. L. Thorndike, an American psychologist, was also interested in the scientific study of learning (6). Thorndike agreed with Pavlov that behaviour was the organism's response to a stimulus, and he was concerned with the establishment of a simple model of learning upon which more complex structures might be built. Although there was this basic similarity and both were pioneers in the scientific study of learning, their approaches to the same problem reflected their different philosophies. Pavlov, one might say, arranged the environment, in the example of the dog, in such a manner that a particular form of behaviour (salivation) was forced to appear; whilst Thorndike provided an environment in which a variety of responses could occur and the learning of one type of behaviour would depend largely upon chance and satisfaction.

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Thorndike's basic experiment was to observe the behaviour of cats confined in a cage, release from which could be effected by the lifting of a latch or some other simple device. The cat's initial behaviour tended to be of a random nature; it would claw, scratch, bite and push its paws through the bars until one particular aspect of this behaviour activated the release mechanism. When the cat was returned to the cage repeatedly, it gradually reduced the time it took to release itself by eliminating the non-effective responses. Eventually the cat would perform only the effective response to secure its own release. Learning had taken place which was gradual and which was the result of the organism's reaction to the environment. It should, however, be noted that this gradual learning process, whilst it may be effective, is not always the most efficient.

Thorndike suggested that the cat, by going through its repertoire of behaviour patterns which already exist, will learn to make the most effective response. As a result of his experiments he proposed three principal laws of learning as follows:

1. *Law of Effect* The first part of this law stated that when a number of responses are made in a particular situation the response which is followed by a feeling of satisfaction, a reward, is more likely to be repeated in a similar situation. In other words, a response to a particular stimulus will by its very success lead to the strengthening of that particular bond. He also stated, in the second part of this law, that responses which were unpleasant or brought little or no satisfaction would not recur. This is, in effect, the rationale behind rewards and punishments.

2. *Law of Exercise* Here Thorndike stated that the responses which occurred most frequently could be strengthened. At first sight this would appear to be valid and to justify constant repetition in school, but the mere mechanical performance of one particular response, without some conscious coupling of the output to the input of the process, that is, 'feedback', will not necessarily result in improvement.

3. *Law of Readiness* This was perhaps the weakest of these three laws. Thorndike proposed that when a response was ready to be linked to a particular stimulus (ready in the sense of the necessary nerve structures being connected) discomfort would be the result. We shall see in a later chapter that more recent physiological studies on the 'all or nothing' principle regarding the firing of the nerve cells (neurons) reveal the weakness of this law. The 'synapse' where the nervous

impulse from one neuron passes to another can either take place or not take place. There can be no feeling of discomfort in these circumstances.

Thorndike was a prolific writer but perhaps his most valuable contribution to learning was a modified Law of Effect. The main modification that he made was his rejection of the second half of this law which dealt with the effect of punishment. In general, modern educationalists accept that reward is a more effective motivation for learning than punishment. Thorndike and Pavlov were similar in the following ways:

1. They were both concerned with the objective study of behaviour and learning through stimuli. Their difference consisted mainly in that for Pavlov one specific stimulus brought about one particular response, for example, clawing, biting and scratching.
2. For Pavlov the food was the stimulus; for Thorndike the goal was the stimulus.
3. In Pavlov's classical conditioning the reward (the food) was given regardless, whereas with Thorndike this was dependent upon learning. Nevertheless both were concerned with the connecting of certain responses with definite stimuli.

After his experiments on animals Thorndike was convinced that learning was a matter of strengthening these connections or associations, and that this knowledge could and should be applied to human learning. G. A. Miller (7; p. 227), referring to Thorndike's laws of effect and exercise, has stated that 'Both of Thorndike's laws are excellent descriptive statements . . . A large part of scientific psychology in America in the twentieth century has been based on, or directed at, these two laws.' Thus Thorndike's work was the forerunner of some important developments.

J. B. WATSON (1878–1958)

Another development of Pavlov's conditioning also took place in America when John B. Watson (1878–1958) made use of Pavlov's theory to account for changes of behaviour in human beings. Watson was the founder of a particular school of psychology known as Behaviourism. He was of the opinion that man was born with certain responses such as the emotions of love, fear and anger, and that learning consisted in the conditioning of these responses to new stimuli. Watson's main contribution seems to have been his inclusion of the role that emotion plays in learning, and the manner in which he reflected the American philosophy towards life. In his approach to psychology Watson reflected his own basic philosophy of pragmatism; he was not only concerned with objectivity, as were Pavlov and Thorndike, but he also saw in Behaviourism the means of improving people's behaviour, predicting it and, if necessary, changing it.

The classical article in experimental psychology by J. B. Watson and R. Raynor (8) described the conditioning of a little child. Their particular interest was in the development of fears in infants, and when observing a baby boy of about 1 year they noticed that he showed no fear of dogs, white rats, masks or burning paper, but that a sudden noise resulted in an emotional reaction such as a startled movement or crying. Watson then set out to condition the baby boy, Albert, to fear a white rat, by pairing the latter with a loud noise. Albert was seated in his high chair and was permitted to reach out for a white rat which was presented to him. At the same time, just as Albert was about to touch the white rat, Watson produced a sudden noise by banging an iron bar just behind Albert's ear without his seeing it.

After about six of these pairings, spread over approximately a week, Albert showed signs of aversion such as crying, withdrawal and dislike of the white rat when it was shown alone. In fact, as in Pavlovian conditioning, generalisations took place and Albert's fears were transferred to other animals, furry objects and even a wad of cotton. Watson had succeeded in conditioning an emotion (R) to a previously unconnected stimulus (S). From this and other similar experiments Watson hoped to convince people that learning was basically the conditioning of these emotions to an ever-increasing number of different stimuli. A diagrammatic representation of his work (Fig. 2) might be compared with that of Pavlov in Fig. 1.

A classroom application of this might be as shown in Fig. 3. The child enjoys the teacher who is teaching him, and this emotion of pleasure is associated with the subject being taught and conditioning takes place.

Pavlov was also interested in a phenomenon known as higher-order conditioning or second-order conditioning. After his dog had been conditioned to respond to a certain sound it was possible to use this

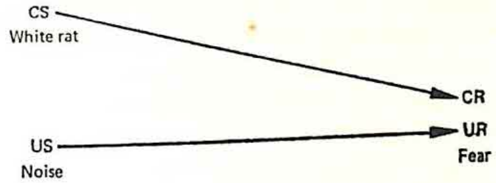


Figure 2

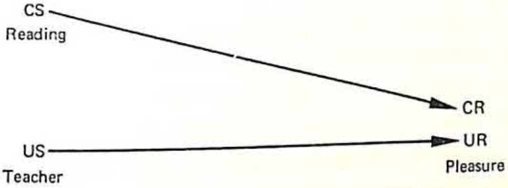


Figure 3

CS in order to condition the dog to respond to yet another stimulus without the presentation of the original US. The dog learned to salivate at the sound of a metronome. Just before the metronome was started a light flashed, and the light was paired with the metronome. After a time salivation occurred with the light only. Let us examine this in diagrammatic form (Fig. 4) and consider its implications as a

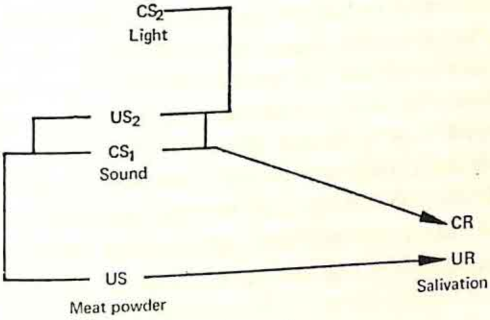


Figure 4

possible development of Watson's theory. The sound becomes the US for the second-order conditioning.

To develop this idea on Watson's model and to show how this might explain failure in school, consider the diagram shown in Fig. 5.

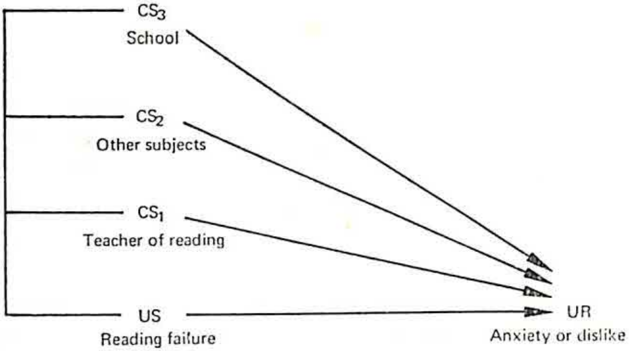


Figure 5

Reading has been particularly chosen as this appears to have such importance for the future scholastic success for all children and is today of vital interest and value.

Watson is perhaps best remembered not for his contribution to education but rather for the application of his ideas to psychotherapy. J. Wolpe (1962) (9) experimented in the removal of unwanted fears, and found that subjects who had developed apparently irrational fears could by this type of conditioning have these fears eliminated. Unfortunately Watson's rather strict adherence to the rigid attitudes of Behaviourism and his objective view of the rearing and educating of children aroused strong criticism. He claimed that by his methods he could train a child to become anything he (Watson) wished, from a lawyer to a thief. Nevertheless, Watson has an important place in psychology; not only did he stress the importance of emotion in learning but also he was interested in the practical application of psychology, and was a strong advocate of the objective study of behaviour. He was also one of the first psychologists to discount instincts and inherited traits and to state plainly and clearly that psychology should concern itself with learned behaviour only. The importance of conditioning has been expressed by B. R. Bugelski as follows:

> 'Conditioning applies to emotional aspects of behaviour. The learner can, in general, be conditioned to respond favourably or unfavourably to his teacher, the content material, the environment surrounding, indeed to anything that can function as a stimulus' (10; p. 68).

S–R learning theorists are often criticised for their narrow and limited view of learning and their inability to take into consideration the specificity of each individual. Whatever the limitations of their work as educationalists, it should be realised that this first attempt at an objective study of behaviour was the foundation upon which scientific investigation into the learning process was built. They have also presented us with concepts such as stimulus, response, conditioning, generalisation, discrimination and reinforcement which are now part of our general vocabulary in psychology. The reader will, no doubt, come to realise, as he progresses through this book, that no single theory of learning will suffice to explain the complex structure of human learning. The S–R theorists indicated that the study of animal learning was important if one were to discover how human beings learnt. From Pavlov to Thorndike, who made the transition to human learning by showing that the same principles applied, and finally to Watson, who was solely concerned with human behaviour and learning, we have an indication of the development of this study.

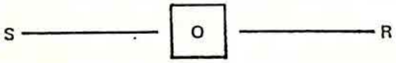
C. L. HULL (1884–1952)

No chapter dealing with S–R theory would be complete without some reference to perhaps the most influential of all theorists, namely Clark Hull. The theorists confined themselves to areas where the influence of the environment was reduced to the minimum, and their reason for this was that the problem of providing laws of learning to meet all requirements of such complex situations in which human learning takes place appeared insoluble. Hull was a Behaviourist in the tradition of Watson, but because of his early engineering training he was more scientific in his approach, and he attempted to construct a precise, logical theory of learning to cover all aspects of human behaviour. A detailed study of his work may be found in his own *A Behaviour System* (11), or in the books by W. F. Hill (4) and E. Hilgard (3). An attempt will be made, however, to indicate the relevant parts of his theory which can be more readily applied to the classroom situation.

Hull's theory of learning is to some extent a combination of the theories of Pavlov and Thorndike and an extension of Watson's Behaviourism; it was, in fact, the first real attempt to consider the organism as playing some part in the learning situation. In the classical

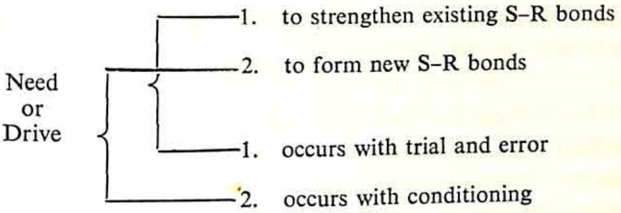
S–R theory objectivity was the key; the organism was stimulated by some change in the environment – a noise or a light – and this was measured as well as the response, such as salivation. It was because only the stimulus and response were observable and measurable that the Behaviourists confined their investigation to these areas. Nevertheless Hull considered it possible that the variety or strength of response varied because of other factors operating within the organism, such as fatigue or previous experience.

Prior to Hull the Behaviourists' theory could be expressed by the simple expression, S–R. Hull's theory would see the necessity of the diagram.



Here O represents the organism. Obviously there are difficulties which arise in the attempt to measure the part played by the organism. Hull attempted to link the inferences one must make about the internal operations of the organism in relation to the stimuli and responses. This he did by formulating seventeen postulates and seventeen corollaries from which various theories could be deduced. Further, he believed that a learning theory could be established by setting up a hypothesis derived from the postulates and corollaries. If the hypothesis failed to stand the rigour of experimental testing then the theory would need to be changed accordingly. Hull also attempted to express the relationships in the chain between the stimulus and response in mathematical terms, as a linkage of 'intervening variables' which were an essential part of behaviour. Prior to this development classical conditioning could adequately be used to explain only simple learning, whereas Hull's theory could be applied to more complex behaviour by consideration of the effect of this link between the intervening variables and the stimulus and response.

As we have already said, Hull's work was to some extent a fusion of the theories of Pavlov and Thorndike. He utilised the classical conditioning of the former, combined with the Law of Effect of the latter under his concept of *reinforcement*. How did this combination take place? Hull considered reinforcement as 'need reduction', and the following diagram is an attempt to show how this operates in Hull's theory:


Need
or
Drive
1. to strengthen existing S–R bonds
2. to form new S–R bonds
1. occurs with trial and error
2. occurs with conditioning

A conditioned response is established if there is a state of need which, in turn, is reduced or satisfied by a successful response. The reduction of need reinforces any S–R connection in existence at that time, and this is in effect the combination of Pavlov's classical conditioning and Thorndike's Law of Effect. Hull firmly established this concept of reinforcement which he developed into primary and secondary types. We shall see in the next chapter the importance of reinforcement in B. F. Skinner's work on instrumental learning or operant conditioning, but for the moment let us consider *primary reinforcement* (12; p. 24). This occurs whenever a response follows quickly upon a stimulus, and as this conjunction of S and *R* is closely associated in time with the diminution of a need there will be an increased tendency for that S–R to recur on later occasions. *Secondary reinforcement* occurs when the S–*R* connection, which has been reinforced by the primary need-reduction, itself acquires the power to reinforce any other contiguous or immediately antecedent S–R connection; and this S–R connection in turn may reinforce any other contiguous or immediately antecedent response.

What is the relationship between all this and the classroom? The majority of both children and adults require some form of reinforcement when attempting any task; they have a need to be satisfied. Young children constantly request attention and praise, and students will express pleasure at essays promptly marked and returned. Indeed, most of us during our school life have been pleased to receive verbal encouragement from a teacher in one lesson or another. To take a simple example, Susan Kenny is busily composing a piece of 'creative writing' concerned with the sound of water running over rocks, and she attracts her teacher's attention as soon as she has completed her assignment. The teacher praises her and Susan, having satisfied her need of approval by the teacher, has been rewarded or reinforced. This is primary reinforcement. Susan's rewarded skill in writing and the satisfaction of her need for the teacher's approval together form the goal from which her motivation arises. When she began her task she did not visualise her completed piece of writing; but rather the teacher's approval, associated with the feeling of satisfaction, became for her the secondary reinforcement, and helped to strengthen the bond between the S and the R. Secondary reinforcement would appear to be essential whenever an action is performed as a means to an end.

In a school this is very important since many children will work hard to obtain high marks or grades. They do this because, in the past at least, these have been associated with parental approval or need-reduction. The marks in themselves are not satisfying but take on the properties of the reinforcers of this feeling of satisfaction, and they become secondary reinforcers; and Hull would see most human behaviour as being activated by this concept of secondary reinforcement. The majority of adults work for some form of social approval or financial rewards, which are secondary reinforcers, and the reduction of the need for these then takes on the characteristics of a secondary drive. E. R. Hilgard (1956) (3) indicates the distinction between secondary drive and secondary reinforcements when he says, 'For example, fear and anxiety easily classify as secondary drives and their reduction is reinforcing.'

Although there might be some confusion about the establishment of secondary reinforcement, the validity of it in operation may be recognised in nearly all learning situations. A mother who continually praises her child when feeding it by repeating such phrases as 'good baby', 'there's a good boy', and other endearments, is using secondary reinforcers. In school it is also essential to use phrases such as 'well done', or 'good work', as secondary reinforcers to motivate children's work.

Whatever criticism may be levelled at Hull's theory it was one of the most ambitious attempted and, although learning was seen as 'chaining of bits', it has practical applications in all learning situations, as well as acting as the starting point for much experimental work. In order to help to clarify 'drive' and 'need', however, it is advisable to consider what a psychologist means by primary drives. These are the expression of physiological needs as hunger or thirst or the regulation of body temperatures. The mechanism which controls these functions is known as *homeostasis*, a simple example of which occurs when a person is too hot, or there is a rise in his body temperature and he perspires, and the resultant evaporation tends to cool the body. Similarly, if the body temperature falls, the individual begins to shiver and thus generates extra heat. If this is not enough to produce a feeling of satisfaction, or reduce the need for warmth or coolness, then other action needs to be taken. If a person is too hot he will remove some clothing, open a window or lower the heating; and if he is too cold he will put on more clothes, close the windows or open the radiators. In other words a change of behaviour has been brought about; and if we refer to the definition of learning as 'a more or less permanent change in behaviour', then simple learning has occurred.

It is obvious, however, that humans perform meaningful actions not just because they are too hot or too cold, or merely hungry or thirsty, nor is their behaviour actuated only by primary drives. The other drives which motivate human behaviour such as drives for social approval or financial reward, are learnt and these secondary drives are part of the conditioning process, as may be seen in Wolfe's experiment (1936) (13). Chimpanzees learnt to accumulate poker chips as a reward for performing complex tasks, and these chips could then be exchanged in a machine, called a 'chimpomat', for food or drink. The chimpanzees learnt to hoard their chips until sufficient were collected to pay the machine. The analogy to money is obvious and in a somewhat similar manner children come to respect many adult social values. Initially the child is in contact with adults who satisfy his primary needs, and because they (the adults) are associated with this need-reduction, their approval becomes a secondary reinforcer. This secondary reinforcement results in a secondary drive and, to revert to the pupil Susan Kenny, this is why she will work to please or to gain approval of the adult in the school, i.e. the teacher.

Hull saw learning as the strengthening of the bond between the S and R, or *habit strength* (sHr). Whenever an S–R bond was formed following a specific S, and this resulted in a need-reduction, this bond was strengthened and learning occurred. The need-reduction is the *primary reinforcement*. If this S–R bond is closely followed by an S (approval), which is associated with the need-reduction, then this S (approval) itself becomes the *secondary reinforcement*. This very S not only acts as a secondary reinforcer but also elicits a drive known as the *secondary drive*, that is, a drive to gain teacher's approval. For Hull, as for Thorndike, the simple connection between S and R was not sufficient for learning. The S–R bond had to be reinforced to build up the habit strength (sHr). Further development of the drive-reduction concept has been undertaken by N. E. Miller (1941) (14), (1948) (15) and (1951) (16).

There are other psychologists who have extended and developed the S-R theory, and the reader's attention is drawn to the work of E. R. Guthrie (1886–1959) whose position was very similar to Watson's, although it was expressed in an even more general way (17). Guthrie attempted to sum up the laws of learning in one basic principle which might be stated thus: when a certain type of behaviour or learning occurs in one particular situation, if the same situation occurs again then the same behaviour is liable to recur. Psychologists such as K. Spence (*b.* 1907), who has extended and modified Hull's work (18), O. H. Mowrer (*b.* 1907), who was originally interested in the learning of emotional behaviour (19), and W. R. Estes (*b.* 1919), who attempted to explain learning in mathematical and statistical terms (20), have made valuable contributions.

Thus, in spite of the limitations and difficulties in attempting to find precise laws, there exists nevertheless a guide to the complex situations of human behaviour and learning. In considering the complex learning situations involved in human behaviour it is necessary to have regard to the factors in this learning which are responsible for such complexity. Such factors include motivation, anxiety, levels of aspiration, interest, expectancy, attitudes and other psychological concepts. Before we consider these, however, we need to look at another aspect of the development of Pavlov's work. This development by B. F. Skinner is known as operant conditioning, as opposed to classical conditioning, and is sometimes called instrumental learning. In the next chapter we shall study the influence of this work on modern educational methods.

To conclude, classical conditioning has indicated the relationship between emotion and learning, and by the development of second- or higher-order conditioning it has helped us to understand in a small way the complex cognitive processes in human beings. It is important to note at all times that the effect of emotion on learning is vital. and that the material to be learnt is related not only to the individual's own self-concept but also to the degree of success achieved. For successful teaching it is necessary to combine the intellectual and emotional aspects of the learning situation.

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Chapter 2

Operant Conditioning and Programmed Learning

From simple learning, and any accompanying emotion, we now turn to a form of learning where emotion is apparently completely absent. This is programmed learning in which the pupil would not be troubled by the varying moods of the teacher. Although this might in some respects be a very good thing, critics of programmed learning are sometimes very concerned with the apparent lack of pupil–teacher relationships. This form of learning is based on the work of Professor B. F. Skinner (*b.* 1904), and it is sometimes known as instrumental learning or operant conditioning.

As shown earlier, in simple learning or classical conditioning the essential basis for learning is the pairing of two stimuli. The first is known as the unconditioned stimulus (U S) which consistently elicits a response, the unconditioned response (U R), while the second stimulus is neutral. As a result of the pairing, the neutral stimulus will elicit the unconditioned response which then becomes the conditioned response (C R), and this stimulus is called the conditioned stimulus (C S).

Operant conditioning differs from classical conditioning in the very fact that the response is not elicited from the organism by the presentation of any particular stimulus, but the experimenter waits for certain behaviour or responses to be emitted first. The response may be necessary for the organism to obtain something or avoid something. Let us consider the basic experiment which will help to clarify the position and enable us later to appreciate the differences between the two types of conditioning. The simple apparatus for the experiment is a box, called a 'Skinner Box', with a lever at one end, and first used by Professor Skinner to study operant conditioning. The lever is connected to a mechanism which delivers a food pellet when the lever or bar is depressed. A hungry rat is then placed inside the box and permitted to explore its new surroundings at its leisure.

Notice that there is here one immediate difference between this exploratory behaviour of the rat and the inability to move of Pavlov's dog, which was strapped in a harness and was unable to execute a similar variety of behavioural responses. The rat eventually presses the lever and a pellet of food is delivered, which it might or might not eat immediately. The animal continues its exploratory behaviour, and each time it presses the lever a food pellet is delivered. When the lever is depressed it is recorded, and after a time it is noted that the rat presses the lever more and more frequently to obtain the food pellet. The rat, in fact, has learnt to operate on the environment to obtain a reward which will satisfy it. This illustrates instrumental learning or operant conditioning, whereby, in the words of B. F. Skinner (1) 'an organism learns mainly by producing changes in its environment'.

The operant behaviour was performed by the organism and was repeated because it was *reinforced* by the presentation of a reward, the food pellet. Harking back to Pavlov's experiment the US (meat powder) was the reinforcement. Each time the CS (the bell or buzzer) was presented salivation occurred with the presentation of the US (the meat powder). The US is thus the reinforcement without which the learning would not take place. Pavlov, however, did not develop this aspect of his investigations. In Thorndike's experiment, however, the escaping from the puzzle box proved to be satisfying to the organism and this was the reinforcement. The bond between the stimulus and response was strengthened, and although Thorndike tended to make little or no distinction between reinforcement and satisfaction it was incorporated into his Law of Effect, which states that an act which is satisfying is learnt whilst an act which is unsatisfying or frustrating is not learnt.

Clark Hull, as we saw in Chapter 1, expanded the concept of reinforcement even further into need-reduction and drive theory and also introduced primary and secondary reinforcement. Sometimes the word 'reward' is used in place of reinforcement, and this is often more meaningful to teachers. Primary reinforcement or reward in school might be the immediate satisfaction a pupil such as Susan Kenny would feel after completing a piece of creative writing, and the secondary reinforcement would be the good mark she hopes to obtain after the work is marked. Further information concerning the whole topic may be found in the works of R. E. Hilgard (2), W. F. Hill (3) and E. A. Lunzer (4).

We are concerned here with the aspect of reinforcement which is used in the sense of reward as when a dog is given a biscuit to eat after it has performed its party piece of standing on its hind legs, or when a teacher praises a pupil by saying 'good work' on returning her piece of creative writing. But before we move on to the direct application of operant conditioning to teaching, it is necessary to see the part played by rewards or reinforcement in Skinner's theory of learning. Skinner's process of operant conditioning depends upon the operant behaviour or response being immediately rewarded. Thus, when the rat in the Skinner Box depresses the lever, a food pellet is immediately presented. Skinner extended his work to pigeons and other vertebrates and was able to teach them to execute many different responses, including performing intricate figures of eight. This process of learning he called *shaping*. Here the experimenter decides beforehand upon the total behaviour he wishes to establish, and whenever the subject (in this case a pigeon) executes a response which is in any way like the total behaviour required it is reinforced. The reinforcement is then withheld until a set sequence is established, each step in the behavioural repertoire being reinforced until the total performance is established. Thus, with patience and frequent reinforcement any set of behavioural patterns can be secured. Skinner noted that the pigeons tended to repeat frequently whatever behaviour they were engaged in prior to the reinforcement, and he called this *superstitious behaviour*, likening it to the superstitious behaviour that human beings perform.

Another aspect of Skinner's work is known as *partial reinforcement*. So far we have accepted that each and every response is reinforced, but we now consider the possibility of intermittent reinforcement. In this type of reinforcement Skinner (1959) (5) shows his similarity to Pavlov by investigating the unexpected with some fruitful results. As Pavlov became interested in the unexpected salivation of his dogs at the appearance of the attendant prior to the presentation of the food, so Skinner, when he reduced the presentation of food pellets, observed that the rat's rate of responding was not necessarily reduced. Partial reinforcement may be arranged in the following ways:

1. *The fixed-ratio schedule* occurs when the reinforcement is given after a set of responses, for example, every fourth, sixth, tenth or even hundredth response. As might be expected the response tends to be fairly constant and relatively high. A variation of this is the *variable-*

ratio schedule in which the reinforcement is given after a different number of responses, say after the third, then the eighth, and then the tenth, with somewhat similar results, namely, a fairly high and steady rate or response.

2. *The fixed-interval schedule* occurs when the reinforcement is given after a fixed interval of time, for example, after every five, ten or thirty seconds. The result tends to be a reduction in response immediately after the reinforcement, which continues at this low rate and then gradually builds up prior to the next reinforcement. A variation of this is the *variable-interval schedule* where the reinforcement is presented at different intervals of time. The result once more is a fairly high and steady rate of response.

This phenomenon is described as *resistance to extinction*, which is, in effect, the number of responses made before extinction begins or the organism fails to respond. Full details of this type of experimentation are to be found in Ferster and Skinner (1957) (6). It is sufficient for us to note here that for initial conditioning constant reinforcement is required, and that a high and steady rate of response may be obtained subsequently by using an irregular schedule. This would appear to have some implications for the school situation. When first a child is taught to behave in a certain way it is necessary to reinforce him liberally, but as the child gradually acquires the necessary skill it becomes advisable to reduce the frequency of the rewards or reinforcements. Thus the same skills will tend to persist when it is no longer possible to apply frequent rewards.

Before we study the practical applications of Skinner's work it may be useful to make some comparisons between classical and operant conditioning. To Skinner the response was all important, and he referred to Pavlov's work as *respondent* conditioning where the stimuli (in this case the whole environment) evoked the response. By controlling the environment one evoked the particular response one wished to obtain. In his own work, however, the organism operated on the environment to change it by emitting responses. Perhaps the most important difference of all between Pavlov and Skinner is the fact that in classical conditioning the reinforcement is *independent* of the occurrence of the CR, whilst in operant conditioning the reinforcement is *dependent* upon the occurrence of the CR.

As Skinner was always ready to apply his experimental findings to practical human problems, especially those concerned with teaching, the applications of his work are not difficult to find. In a paper which he presented to a conference on 'Current Trends in Psychology and the Behavioural Sciences', held at the University of Pittsburg on 12 March 1954, he discussed some of the problems and inefficiency of classroom teaching. He was at pains to show that learning in school could be greatly improved if teachers knew more about reinforcement and the correct way to apply it. He made some interesting remarks about the use of reinforcement fifty years ago, and commented that, 'The child read numbers, copied numbers, memorised tables and performed operations upon numbers to escape the threat of the birch, rod or cane' (1). These were aversive, but even today, he continued,

> 'the child at his desk, filling in his work book, is behaving primarily to escape from the threat of a series of minor aversive events – the teacher's displeasure, the criticism or ridicule of his classmates, an ignominious showing in competition, low marks, a trip to the office "to be talked to" by the principal, or a word to the parent who may still resort to the birch rod' (1).

Punishment according to Skinner is of little value in encouraging learning since it suppresses behaviour only temporarily. This was demonstrated experimentally in a Skinner Box when each time the rat depressed the lever it received a mild electric shock. Although at first it ceased to press the lever, after a time it repeated this behaviour indicating that the effect was soon lost. As W. F. Hill (3; p. 64) says, 'Thus punishment is both a rather unreliable technique for controlling behaviour and a technique that is likely to have unfortunate side effects.'

Reinforcement, in the form of positive reward, was the message that Skinner wished to impress upon teachers as the real practical application of his research. In his article, 'The Science of Learning and the Art of Teaching', he discussed the inefficiency in the use of reinforcement by the teacher which, as illustrated previously, was often aversive and not immediate. Children, he suggested, progressed through a vast number of answers before any were corrected, and so there was a gap between response and reinforcement. When the reinforcement was supplied in the form of ticks or marks the period of time which elapsed was often so large that the system had little or no effect. In any learning situation it was essential that progressive stages be worked through in order to reach the final complex behaviour, with each stage being reinforced. The teacher found this impossible to do individually and often resorted to block marking because it was impossible to deal with each pupil's individual steps. In this way a whole page of work or a vast number of calculations would be marked at once. This relative infrequency of reinforcement Skinner regarded as 'the most serious criticism of the current classroom' (1). In the average classroom the pupil is dependent upon the teacher alone for reinforcement and as there are thirty to forty pupils in many classes today, the individual is likely to receive infrequent reinforcement. However enthusiastic or dedicated a teacher may be, he cannot devote time and attention to this number of pupils at the same time; therefore Skinner would argue that mechanical help must be provided to ensure that each child receives immediate reinforcement as far as possible. This could be accomplished through programmed learning.

Programmed learning is the use of teaching machines, and of programmed texts which are often printed in book form. The actual material is to some extent irrelevant to our study as we wish to consider how Skinner's theory of learning can be applied in a practical manner; but the different forms of programmed material have a number of common characteristics. An item of information is supplied to the pupil who is required to answer a question on this information; he has to make a response and be informed immediately whether he is right or wrong. If he is right he is presented with another unit of information; if he is wrong he is presented with further information concerning the same question until he makes the right response. In this way the pupil proceeds at his own pace, the brighter pupil moving at a faster rate than the slower pupil.

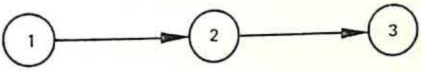
Programmed learning is, of course, not without its critics and some have argued that it is a process whereby the pupil-teacher relationship is ignored or destroyed. Dr B. Fine (1963) has researched into the various types of machines and programmed texts in current use in American schools, and he has made an investigation into students' responses and teachers' reactions. Although in favour of programmed learning he does indicate that in his view 'the greatest value of teaching machines appears to lie in "tool" subjects in the fields of mathematics, science and language which deal with measurements, rules, or natural laws' (7; p. 120). In the same work he writes that, 'Machines can grapple with facts, but they cannot teach imagination, emotional or artistic sensitivity, or the intellectual insight which relates widely different ideas'; and he adds that, 'Dr Skinner has developed a program to help a student memorise a long poem, but he has not yet found one which will teach a student to enjoy poetry!' (7).

As early as 1926 S. L. Pressey (8) suggested a machine with questions and multiple-choice answers. The student pressed the button which coincided with his choice; if this were correct the machine moved on to the next piece of information and multiple-choice answers. This was really a testing machine which taught only incidentally. The majority of teaching machines today are based upon the following principles of Skinner's psychology:

1. *Operant Conditioning* Most human behaviour consists of emitted responses, and learning is the controlling of the rate of these responses.
2. *Reinforcement* When a response is emitted by the organism it is possible to ensure its repetition by praise or simply by letting the person know that he is correct.
3. *Immediate Reinforcement* The correct response should be immediately reinforced to ensure that it is learnt.
4. *Shaping* Complex behaviour may be learnt by the reinforcement of each individual step in the sequence. The first step is reinforced, then the next step and the first one together as a unit, then this unit and the next step together until the whole sequence is built up.

Skinner built his first teaching machine in 1953. His programmes are *linear* programmes as opposed to the *branching* programmes; these are sometimes referred to as 'extrinsic' and 'intrinsic' programmes respectively. An intrinsic programme is one in which the student's own responses will determine the route to be followed, whilst an extrinsic programme defines the route to be followed irrespective of responses. In linear (Skinnerian) programming, all students proceed through the same information in the same order. They do not select their response from a number of multiple-choice answers but construct it by writing down what they consider to be the correct answer. Then, if they are using a machine, they turn it to the next item, or if they are using a book, they turn to the page or frame indicated. Frames are short sections into which the whole programme is divided. In this way the students will find not only the next item but also the correct answer to the previous question.

In linear programming the steps are extremely small in order to eliminate the possibility of a student writing an incorrect response or answer. Skinner considered it wasteful and harmful to condone incorrect answers, so that mistakes should be kept to the absolute minimum as these might be learnt in place of the right answer. J. P. Lysaught and C. M. Williams (9) describe this type of programming as follows: 'The linear or extrinsic programme presents a sequential development of the material through which each student, regardless of his response, proceeds in exactly the same order.' A diagram of the process would look like the one shown here:



Skinner makes use of the important psychological fact that not only is reinforcement immediate but the physical writing of the response is an actual part of the learning situation. By not presenting a number of alternative multiple-choice answers from which the student has to select, he also utilises the commonly-held opinion that recall is more efficient for learning than recognition.

This, then, is one type of programmed learning, but some obvious educational defects do exist. A number of these are not necessarily part of the underlying psychology but more the outcome of carelessly or incorrectly prepared texts. It is true that programmes are limited in their application and quickly become out of date if not constantly revised; but they also seem opposed to the movement towards progressive education in which the child is encouraged to investigate and to discover facts for himself. D. Unwin and J. Leedham (10) express this problem for programmed learning in the following way:

> 'A philosophy of education which suggests instruction rather than discovery has obviously a strenuous time ahead of it in today's educational scene. It is necessay to look a little deeper than the surface to appreciate that programmed situations in the primary school are one certain hope that liberal and progressive methods of learning using small groups and individual patterns shall continue . . . The teacher with programmes and with programmed situations will be the best fitted to move the children forward.'

Even in the teaching of the sciences and mathematics, where Dr Fine (17) would see its greatest contribution, the application (or perhaps introduction) of the Nuffield Science and Mathematics projects tends rather to move away from programming. The criticism that such programming has difficulty in teaching the more liberal subjects and humanities is probably justified, for these complex subjects would appear to require more than just immediately reinforced steps. There are many topics in which alternative views need to be expressed and considered, and it may well prove to be impossible to accomplish this by proceeding through the easy steps of a linear programme. Nevertheless, it appears that this type of programmed learning has certain advantages which B. F. Skinner (1961) (11) has listed as:

1. The student is frequently and immediately reinforced.
2. He is free to move at his natural rate.
3. He follows a coherent sequence.

Dr B. Fine (17) lists the following three advantages:

1. Through individual instruction the brighter child is able to advance faster, whilst the others may go at their own pace.
2. The teacher is freed of a great deal of routine work, and is thus enabled to do more creative teaching.
3. The techniques of teaching will improve since the teachers will get the best scientific and educational approach to learning.

Let us now consider the type of programmed learning referred to as branching programmes, of which Dr N. Crowder is regarded as the founder. When employed by the United States Air Force as a psychologist he was concerned with the problems of training technicians to service the complex navigational equipment of aircraft, and developed intrinsic or branching programmes to help overcome these problems. In branching, the pupil's mistakes play an important part in his progress. Crowder accepts that there is some uncertainty as to the manner in which individuals learn, but he assumes that the starting point and the destination are the same for all. The route between these two points varies to some extent, dependent upon the errors made by the individual. These errors act as the starting point for the next stage for the learner, and the most effective way of reducing errors is by explaining them to the student. A branching programme might be represented as shown in Fig. 6.

The initial frame would probably consist of a short passage of not more than seventy-five words to be read by the student. Frame 2 would consist of multiple-choice questions to answer. If the correct answer is chosen then the learner moves on to Frame 3. If the answer

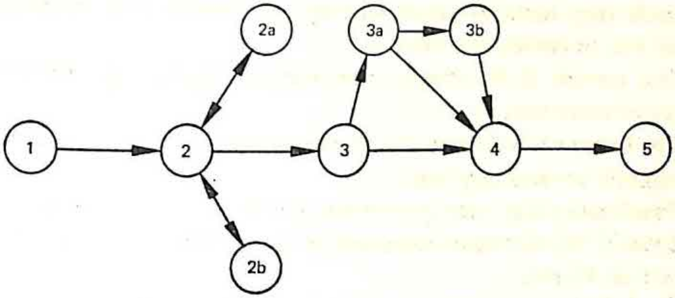


Figure 6

is incorrect the learner is told he is incorrect and is either directed back to the original frame or to another sequence where the material is represented in another form, and then finally back to the main line. If the learner fails at 3 (as in the diagram, for example), he is directed to 3a where, dependent upon his success there, he either progresses back to the main programme to 4 or is channelled to 3b before returning to 4. In this way the learner's errors are an important part of the feedback technique and are built into the programme itself.

At this stage it is perhaps relevant to list some of the format behind each type of programming, linear and branching; but before this is done it is necessary to consider the common ground between them. Both types of programmes have the following characteristics:

1. Information is presented to the learner.
2. The learner is required to respond to the question or problem displayed.
3. The learner is informed immediately whether his response is correct or incorrect.
4. The response is required in an overt manner, usually in writing, or by the activation of a mechanical device to move the machine on to the next frame.
5. The sequence of the programme and of the information presented is vital.

LINEAR OR EXTRINSIC PROGRAMMING (B. F. SKINNER)

1. The material is arranged in small, simple and sequential steps.
2. The learner is unaware of any difficulty in the material.

3. Each step requires an active response which tests whether the learner has understood or not.
4. The learner is informed immediately whether the response is correct or incorrect.
5. The learner is led through complex material by reinforcement of each simple, correct response.
6. The learner is correct approximately 90 per cent of the time.
7. Even if the learner is incorrect he only notes this and proceeds to the next frame.
8. Each item is designed to evoke the correct answer.
9. The material is arranged in fixed sequence through which all learners, regardless of success or failure, pass.
10. Each learner proceeds at his own pace.

BRANCHING OR INTRINSIC PROGRAMMING (N. CROWDER)

1. The material is arranged in simple, sequential steps.
2. Different sequences or routes are provided for different individuals.
3. The choice of route depends upon the individual's response to previous materials.
4. Each response acts as a starter for the next move.
5. The learner is informed immediately whether he is correct or incorrect.
6. Errors or incorrect responses are explained to the learner.
7. Incorrect responses act as indicators for the necessary route for the individual learner.
8. Each learner proceeds at his own pace through different routes.
9. Multiple-choice questions are used requiring a variety of answers.
10. Information is provided in relatively large quantities.

From the above it will be clear that there are areas which are common to both and other areas where there are differences.

In order to assess the value and advantage of each type of programming one must consider how both types compare with any accepted criteria of successful education. Any teaching programme has to consider when certain material should be introduced, bearing in mind the levels of readiness of the pupils. All supporters of programmed learning would claim that this type of teaching permits the teacher to ensure that each individual member of the class is ready, in the sense of maturation, intellectual development, and social maturity. It is also generally accepted that the material presented to children should follow in a logical sequence in units sufficiently small to permit the establishment of one step before proceeding to the next. The examples and concepts to be taught need to be graded in difficulty and presented in a variety of ways to ensure complete understanding. Sufficient time has to be allowed for practice, and work must be corrected as soon as possible, preferably in the presence of the pupil. It is also often recommended that some form of testing should be built into the course so that individual errors may be diagnosed and remedial steps taken. These criteria are to some extent met by programmed learning.

There are, however, other areas of teaching with which opponents of 'automatic' teaching are concerned. The relationship between the teacher and taught is, they argue, an integral part of the learning situation. The development of the powers of communication can arise only where the pupils have opportunities to present their ideas, thoughts and queries to another human being. This is difficult to do with an inanimate object such as a programmed book or teaching machine. They would also claim that there was little room for the individual to vary this response or approach to the work set. Branching programmes would appear to attempt so solve this problem, but the limits are obviously the size of the programme. The learner has no opportunity of testing his own theories against peers and it can be argued that the development of thought requires this interplay of ideas. It may be asked whether the characteristics of self-reliance and independence are fully developed through programmed learning, or whether the learner comes to rely upon the 'machine' only as the stimulus for learning. All these are the more general points to be carefully considered, but there are other more specific points:

1. What is the teacher's role to be? Is he a mere provider of materials or a super-technician?
2. Is auto-instruction feasible for all areas of the curriculum? Certain disciplines might appear to fit more readily into programming than others.
3. Who is to write programmes?
4. Once they are written who is to evaluate them?
5. What part does motivation play?

These are not questions that we propose to answer here. It is necessary, however, for teachers to have some knowledge of the actual type of programmed-learning aids which are available. The most simple type is the *programmed textbook*, an example of which is the Tutor Text. In this the learner is first given a short discussion of the relevant material, and this is followed by a multiple-choice question. The alternative answers have each a page number beside them, and the learner chooses which he considers to be correct, then turns to the appropriate page. If he is correct he is informed so and he proceeds to the next item; but if he is incorrect the text explains his error, enlarges upon the original text and often directs him to return to the original question to make another attempt. This process is repeated throughout the book and is based on branching or intrinsic programming.

A more sophisticated development of these books is the simple, manually operated machine such as the 'Didock 506', 'Min-Max', and the 'Esatutor'. The basic principle is the same although linear programming is often used. This principle is that a small unit of information is given to the student, who makes an overt response; then either by turning a handle or by pressing a button he is taken to the correct answer and so proceeds through the programme. There are now on the market a number of highly sophisticated machines, electrically operated, which use a variety of media including 35 mm film strips, motion pictures, synchronised tape-recorders, animated models and written texts. The learner responds in a variety of ways, by writing, by speech and in some instances by using some form of manipulative activity, such as the 'Empirical Tutor'.

There is also a type of teaching machine which requires the use of a computer. Gordon Pask, a British electronics engineer, was investigating problems associated with the acquisition of manual skills, and he became convinced that simple programming was inefficient because it did not take into consideration such factors as change of attitude, interest and fatigue. These, as all would agree, do occur and do change during a course of study. Consequently Pask considered it necessary to design a machine which would adapt to the change in the learner. The machine would learn the behaviour patterns of the students and would adapt or construct the programme on the basis of this information. The computer was required to build up a memory bank of the individual learner's performance; such items as speed, accuracy and the error rate would be recorded and the level of difficulty of the programme would be adjusted accordingly. The machine became known as SAKI, or 'self adaptive keyboard instructor'. One of the most intricate of these machines is Plato II, which is housed at the University of Illinois, and which with the aid of a complex computer can handle 128 students at a time.

A list of programmes available may be found in G. O. M. Leith's *Handbook of Programmed Learning* (12). We conclude with a brief excerpt from a textbook which utilizes the principle of the branching programme. It should be noted in this example, taken from Patrick Thornhill's *The Waterloo Campaign* (13), that an incorrect answer necessitates an alternative route through the programme.

> 'It is 1815. On 1st March the ex-Emperor of the French, Napoleon Bonaparte, has landed in France, with a tiny force of grenadiers, from his exile on the island of Elba. The French are already tired of their restored Bourbon king Louis XVIII, and soon the army declares for Napoleon once more and Louis is in flight. But the Allies, gathered for the peace conference at Vienna, sink their disagreements and the four great powers, Great Britain, Prussia, Austria and Russia, each agree to put an army of 150,000 men into the field and keep it there, with a subsidy of £5 million a month from Great Britain, until Napoleon is finally defeated. By June, Napoleon has gathered an army of about 160,000 Frenchmen.
>
> A British-Netherlands army of 110,000 under Wellington and a Prussian army of 117,000 under Blücher, are gathering in Belgium and are waiting for the Austrians (210,000) and Russians (150,000) to reach the Rhine about 1st July, when the invasion of France is to begin. (See Map 1.)
>
> What should Napoleon do?
>
> Await the invasion and fight a defensive campaign?
> (If this is your choice, turn to Section 3)
> Attack the armies waiting in Belgium?
> (If this is your choice, turn to Section 5)
> Advance against the Austrians and Russians?
> (If this is your choice, turn to Section 6).'

Thus, programmed learning includes material ranging from single printed sheets to textbooks and a wide variety of sophisticated machines. Whatever its limitations, in apparently failing to consider the wider social aspects of learning including teacher–pupil interaction, it has the advantage of reducing inter-pupil competition to a minimum. There is a sense in which the pupil, in working the programme, is competing with himself, with his previous competence, skill and speed. At the same time, if the programme is carefully designed, its steps and element of difficulty will always remain within the pupil's competence.

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Chapter 3

Insightful Learning

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In the previous chapters we have considered learning which takes place when a permanent connection is made between a stimulus (S) and a response (R). The work of Pavlov, Thorndike, Hull, Watson and also Skinner was based upon this principle. The essential difference between Skinner and the others is that, in classical conditioning, learning is dependent upon the strengthening of existing connections, whereas in operant conditioning Skinner maintains that there are a number of responses not initially linked with any particular stimulus. Learning, he suggests, consists in establishing new connections between any stimulus and response. This is one reason why he prefers to call them 'operants' rather than responses since they are not at first a specific response to any specific stimulus; hence we have operant learning or operant conditioning. Nevertheless, the basis of all their work was developed from the Associationists and their idea of the 'chaining together of bits'. Skinner's use of the term 'operant conditioning', however, tends to reduce the whole of learning as a way of behaving, and to minimise the element of purpose involved, and the concept of learning as a means of achieving.

In the present chapter we are going to study a totally different kind of learning, which is not dependent upon any stimulus and response but which results from insight. Most readers will have had the experience in which, by a sudden flash of inspiration, they have suddenly and completely solved a problem or puzzle. As it often happens, the psychologists who first emphasised the importance of this type of learning were not primarily interested in learning *per se* but were concerned with other areas of study, such as the investigation of visual perception. It was because they recognised that the basic principles of perception were also applicable to learning that they transferred their interest to this topic. No attempt was made, as Hull did, to construct a comprehensive theory to cover all aspects of learning, but they made a valuable contribution to this field of study. Their work originated in Germany during the early part of the present century; eventually, driven into exile by the Nazis in the 1930s, they established themselves in the USA.

The most important leaders in this new field were W. Köhler (1887–1967), F. Koffka (1886–1941), M. Wertheimer (1886–1943) and K. Lewin (1890–1947). These and their followers were known as Gestaltists because they emphasised the importance of the *Gestalt*, a German word meaning the form, pattern or meaningfulness of the whole. Previously meaningfulness in perception had been largely ignored, and the study of this phenomenon had mainly been concerned with the different thresholds of perception as investigated by E. H. Weber and G. Fechner in the early nineteenth century.

Perception has always interested philosophers and scientists and is the logical starting point for the study of behaviour if we accept that the latter is the interaction of the individual with the environment. The Gestaltists emphasised the organisation of perception into 'good form', or 'good pattern' based on simplicity and symmetry. This organisation would appear to develop partly through learning and experience and partly through maturation. Jean Piaget, whose work we shall consider in a latter chapter, illustrates how the development of the child is largely dependent upon his ability to organise cues. Not only must we bear this in mind, but also it is necessary to appreciate how the Gestaltists differed from the Behaviourists who, although they were in some revolt against the Associationists and their introspective methods, still regarded learning as the connecting together of discrete elements.

M. Wertheimer became one of the leading personalities in the movement when he illustrated the seeming futility of splitting the whole into separate parts by his investigation of the apparent movement of lights when one light bulb is switched off and another in close proximity is switched on. This phenomenon is the basis for electrical advertising signs, and as we watch we tend to see a continuous movement. Wertheimer argued that it was pointless to break this movement down into its separate components since the mind immediately concluded that there was movement. It did not go through the laborious process of diagnosing one light bulb switched off, then the next switched on, and finally concluding that there was movement. It was pointless, Wertheimer suggested, to analyse the whole scene into discrete elements or parts. As he comments in *Productive Thinking*

'In their [the Associationists] desire to get at the elements of thinking they cut to pieces living and thinking processes, deal with them blind to structure, assuming that the process is an aggregate, a sum of those elements' (1; p. 237).

From the *phi phenomenon*, described above, arose a study of learning through perception of the whole structure. The Gestaltists proposed four laws of perception which together provided a general principle known as *Prägnanz*, which connotes meaningfulness, completeness, relative simplicity and good pattern. This principle asserted that the subject structured the perceptual field in as simple and clear a manner as possible to give meaning to it. These four laws are as follows:

1. *Law of Proximity* This refers to the way in which parts of a visual field close together tend to become integrated as a complete and separate unit. An example of this occurs when a number of parallel lines are drawn on a sheet of paper with different spacing, and they are not seen as a mere series of individual lines but as groups of two (see Fig. 7).

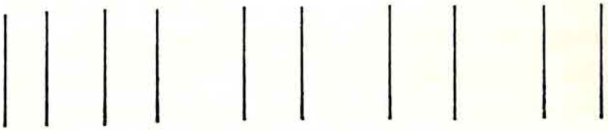


Figure 7

2. *Law of Closure* This states that where there are gaps in a visual field the observer will tend to close them in order to organise them as meaningful wholes (see Fig. 8).

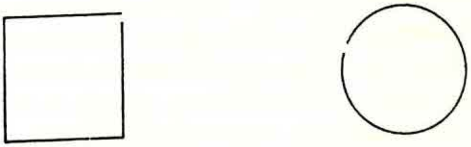


Figure 8

3. *Law of Good Continuation* This is similar to Law 2. Here the gap in a visual field may be completed in the middle as well as at the end (see Fig. 9).

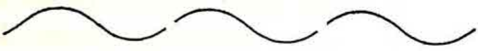


Figure 9

4. *Law of Similarity* This states that in a visual field we tend to pick out and group together as a unit the parts which are similar. In Fig. 10 we see three rows of crosses and two of noughts; but if we turn the page through 90 degrees we see columns rather than rows.

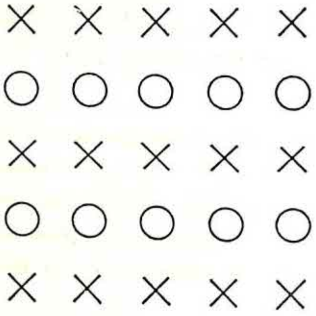


Figure 10

It was through these principles that the Gestaltists moved from the examination of perception to the study of learning, and to the imposition of structure, coherence and organisation through which perceptional experience might be transformed (2; p. 145).

A child learns to discriminate between objects and to recognise shapes in the course of handling them, and this discrimination is the result of the interaction of maturation and experience. It has been observed that patients operated on for the removal of a cataract when blind from birth are unable to discriminate between different objects and various geometrical shapes for periods varying between days and weeks. Recognition would appear to be dependent upon the combination of seeing, feeling and movement. Some discrimination may or may not be innate in the human organism, such as the discrimination of light and dark or sound, and the only real test is the different reaction. This is known as perceptional learning, and may be pursued further in M. D. Vernon's *The Psychology of Perception* (3).

The Gestaltists' work connected with insight has proved to be their most important contribution to learning. It was Wolfgang Köhler's studies of learning in chimpanzees, described in *The Mentality of*

Apes (4), that really began this field of investigation. Köhler was a German psychologist who went from Berlin to Teneriffe in 1913 to work at the anthropoid station founded by Professor Rothman of Berlin, and because of the outbreak of the First World War was marooned there until the cessation of hostilities. There he performed a number of experiments with chimpanzees. A typical experiment is where a chimpanzee is confined inside a cage; outside the cage would be a bunch of bananas just out of reach, whilst inside the cage would be a stick. After a number of unsuccessful attempts to reach the fruit with his arm the chimpanzee would have a sudden 'insight'; he would use the stick as an extension of his arm and rake the fruit towards him. (It is, of course, impossible to say how far this 'insight' was preceded by reflection on the part of the chimpanzee.) In another experiment the fruit would be hung from the ceiling of the cage out of reach and climbing possibilities, and inside the cage there would be placed a box. After a few vain attempts the animal would use the box to stand upon to reach the fruit. An extension of this experiment would be to provide two boxes neither of which alone would be of sufficient height to reach the fruit. The chimpanzee was required to stack the boxes before he was able to achieve success.

Perhaps the most revealing experiment occurred where the animal was required to join two sticks together in order to reach the fruit. Once again the fruit would be outside the cage, and within the cage would be placed two sticks neither of which would be of sufficient length to reach the fruit. The chimpanzee would try first one stick then the other. After many unsuccessful attempts, eventually in the handling of the two sticks the chimpanzee would accidentally join them together, and immediately he would take the joined sticks to the bars and drag in the fruit. Even if the sticks separated on the way he would soon rejoin them. This represents the sudden or 'insight' solution of the problem which the Gestaltists claimed.

Let us compare this interpretation of learning where the animal appears to find a sudden solution to the problem and that of Thorndike. In Thorndike's experiment the animal was confined in a cage and attempted to release himself by unfastening a catch. Köhler criticised this experiment mainly on the following grounds. Firstly, he claimed that it was unfair to expect the animal to find the solution when the clues necessary were hidden from the animal and were outside its field of vision. The release mechanism, a lever or catch, was usually hidden away outside the cage. Secondly, the behaviour required was not natural for the cat and therefore success could be achieved only by chance through random trial and error. Another important difference is that Köhler's animals would be able to solve similar problems again both at a later date and in somewhat different circumstances, whereas Thorndike's cats would be unable to transfer their previously acquired knowledge.

This ability to transfer learning is an important concept and we shall consider this in a later chapter. Some psychologists argue that the distinction between the two experiments is basically the difference between automatic learning and thinking. They consider that Thorndike's cats gradually acquire the ability to release themselves simply by constant repetition, as shown by the fact that there is only a slow decline in the time taken for success, and the animal shows no indication of having achieved a sudden solution to the problem. This is similar to the attempt by a human being to solve one of those puzzles in which two bent nails are entwined. It is possible to achieve a solution either by randomly jiggling the puzzle around or by suddenly arriving at the solution after mentally observing the variety of possibilities. If the latter takes place then it should be possible for the learner to transfer the solution to any other problem of a similar nature, whereas if the former occurs then the subject would merely repeat the variety of procedures he performed previously.

E. A. Lunzer (5; p. 15) lists the following as characteristics of insightful learning:

'(1) Suddenness of solution.
(2) Immediacy and smoothness of behaviour after solution.
(3) Ability to repeat solution without error on successive presentation of original problems.
(4) Ability to transpose the solution to situations exhibiting the same relational or structural features, but in a different context.'

Köhler observed in his experiments that the behaviour of his chimpanzees was not mere blind trial and error but that there was purposiveness and insight into the whole problem and restructuring. This restructuring is an important concept in Gestalt psychology, in which the structure is the composition, the arrangement of component parts, and the organisation of a complex whole, forming units of experience. There would be occasions when weak structuring might lead to a poor insight, resulting in a failure to solve the problem because certain essential features had been missed. Most readers will have experienced an occasion when, in attempting to find the solution to a certain problem, they have found themselves reverting to the same mode of thinking which they realise is fruitless. Children in school will often continue with the same approach even when they know their solution is incorrect. This idea of progressive structuring and restructuring would appear to be closely linked to the Gestalt interpretation of memory. This is, of course, as it should be because the Gestaltists based their work on memory largely on the same principles as they applied to perception. Any perceptional impression is in itself a Gestalt which leaves a memory trace which is liable to undergo changes either towards a 'good Gestalt' or a 'bad Gestalt'. The former will more likely be retained than the latter which will tend to disintegrate and might perhaps become attached to other traces. Joan W. Reece aptly highlights the Gestaltist viewpoint as compared with that of other psychologists when she writes:

> 'Simple level insight looks as though it involves the noticing, recognizing and grasping of relationships, which amount to the processes intelligence theories have defended. Gestalt psychologists, however, do not think in terms of items that are related. Instead they stress the perceptual grasp of wholes in which, at most, relatively isolated elements and relations are embedded, these taking their character, in part at least, from the nature of the whole in question' (6; pp. 274–5).

Up to the present we have tended to orientate our discussion towards animals. Köhler's work was connected with chimpanzees but M. Wertheimer (1; p. 65) demonstrated that similar processes occurred with children. In one example he taught children how to find the area of any parallelogram after understanding how to find the area of a rectangle. He describes how he visited a classroom where the teacher was teaching the class to find the area of a parallelogram after revising the area of rectangles. This was taught by the conventional method of dropping the two perpendiculars as in Fig. 11. With

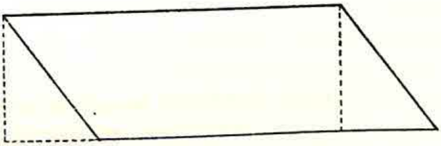


Figure 11

the help of this diagram and the usual explanation the area of the parallelogram was established as the base multiplied by the perpendicular height. Examples were set and extremely satisfactory results obtained. Wertheimer then explains how he asked permission to set the class a similar example. He drew a parallelogram as in Fig. 12. This confused a number of the class who attempted blindly to drop perpendiculars as in Fig. 13, and became extremely puzzled.

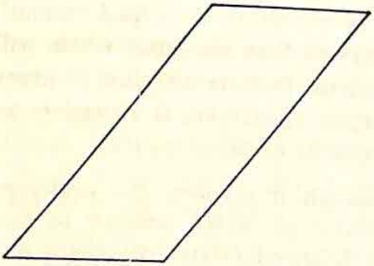


Figure 12

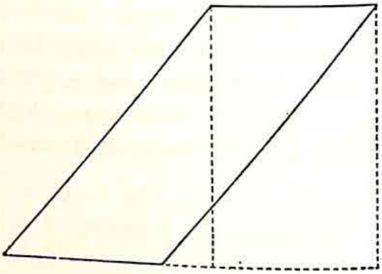


Figure 13

A minority realised that Fig. 12 was similar to Fig. 11, only that it had been rotated. They therefore turned their pages through 45° as in Fig. 14 and successfully solved the problem.

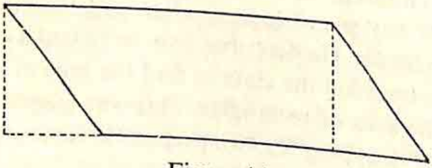


Figure 14

Wertheimer stresses that insightful solutions depend upon the structural features of the problem being presented in a variety of ways. Although the class had been taught a number of problems with different measurement they were all perceptually similar to that in Fig. 11. He went on to demonstrate that younger children who knew no Euclidean geometry at all were able to solve analogous problems involving the area of the trapezoid, as in Figs. 15, 16 and 17, by converting the figure to rectangles, because they had grasped the perceptual structure. As Wertheimer says:

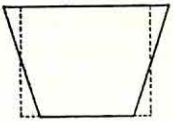


Figure 15

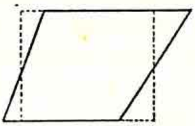


Figure 16

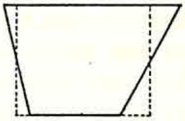


Figure 17

> 'But if they have grasped the problem – and this is what grasping means – then they see the lines in their structural role and function, in their meaning within the sensible context. They see how these lines, just these in this situation, bring about the solution in the inner relatedness, the structural relation of these operations to reaching the goal' (1; p. 65).

H. G. Birch has demonstrated the importance of past experience in the insightful learning of chimpanzees (7). In his experiment chimpanzees were confined in a cage with some food out of reach outside the cage, and a hoe was provided by means of which they could rake in the food. Out of the six animals tested four failed completely, the fifth solved the problem by trial and error, and the sixth appeared to show insight. Birch then for the next three days provided the animals with some short straight sticks to play with, which the chimpanzees used after a period of experimenting for prodding, shovelling and a variety of other activities. The chimpanzees were then retested and were able to solve the problem with ease. If one saw only the second experiment it would appear that they all showed insight immediately. Why is it then that these results are so different from those of Köhler? One possible explanation is that the chimpanzees used by Köhler in their previously natural state had acquired or learnt the variety of uses of a pole or stick. It would appear feasible that they had been used to playing with broken branches of trees and that this past experience was utilised when they were set the problem of raking in the food. The new situation would obviously be similar to that which they had experienced before.

Another psychologist, H. F. Harlow (8), also demonstrated that insightful learning appeared to be dependent not only upon previous experience but also upon previous trial and error learning. In a series of experiments a monkey was presented with a variety of discrimination tests. The simplest experiment of the series was the one in which the monkey had to select from two objects placed on a board. For each test the two blocks were easily distinguishable and clearly different in either size or colour. For example, one might be white and the other black, one cylindrical and one triangular, or one large and the other small. The monkeys were presented with a board on which were two different blocks, under one of which the experimenter had previously placed a reward, for example a raisin or some peanuts. The monkey was allowed to look under one block, and if correct he was given the reward. The experiment was then repeated with the same blocks in different positions, on the board, and the reward was always under the same block. When the monkey was able to select the correct block first, in fact when he had learnt which one to choose, the blocks were changed. The trial was repeated with different shaped blocks until the monkey was again able to select the correct object each time. This in itself would be simple trial and error learning, or one could say that the monkey had learnt to respond to a certain perceptual cue only – either the size, the shape or the colour.

However, by presenting a long series of trials Harlow observed a distinct change in the behaviour of the monkeys, for the animals gradually developed a strategy to solve the problem. They learnt to switch their choice, if incorrect the first time, to the other object. They had, in fact, achieved two facets of learning. Firstly, they had learnt to discriminate; for example, when two objects were presented of a cylindrical and triangular shape, they would realise that the cylindrical object was the correct one and would choose this one hundred per cent of the time. Secondly, when different objects or blocks were presented, they learnt that if their first choice were incorrect they must immediately switch choices. Harlow called this a 'learning set'.

Harlow experimented with a variety of these discrimination problems. His monkeys had to select the odd block out of three, and this they accomplished after a number of trials. He also developed a more sophisticated experiment in which the colour of the base on which the blocks were placed was changed. In this experiment the monkeys would have to learn to select (say) a triangular-shaped block if the base was yellow, or a circular shaped block if the base was green. As it will be appreciated, there was a large number of variations and combinations of the colours and shapes used. Harlow also performed these experiments with children aged between 2 and 5 years, and he discovered that the brightest monkeys learnt more quickly than the duller child in the first type of experiment, whilst in the pure discrimination problems with three objects the monkeys were generally quicker than the children.

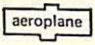
Harlow argued that this acquiring of learning sets, or 'learning how to learn', was the natural progression from the random trial and error learning of Thorndike's cats to the apparent insightful learning of Köhler's chimpanzees. If we accept that one of the ultimate objects of learning in school is to solve problems, or to develop reasoning capacity, then to permit children to operate at the mere trial and error stage would be extremely wasteful; but one could not expect them to acquire insight unless they had previously acquired the learning set of any particular type of problem. There are of course areas in education where a learning set cannot be achieved, nor can insightful learning take place. As R. M. Gagné says,

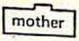
> 'A child cannot learn the names of plants or stars in an insightful manner. He cannot learn to read by insight nor to learn a foreign language. A student of biology does not learn the structure and functions of animals by insight. In short, insight cannot be a prototype for a vast amount of learning that human beings ordinarily undertake' (9; p. 17).

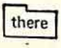
For those who consider that Gestalt psychology has much to offer practising teachers the above statement by Gagné, that a child cannot learn to read by insight, would immediately refer them to the 'look and say' method of teaching reading.

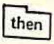
There are two major methods in the teaching of reading, namely, 'phonic' and 'look and say'. The former method is based upon the fact that the English language is alphabetic and sequential; in other words, a child has to learn his sounds and alphabet and the progression necessary from left to right. It is argued that words are made up of letters which combine together to give certain sounds. The combination of these letters and sounds, when read in a natural order from left to right, produces words of different lengths dependent upon the combination of the number of syllables or sounds. In this way a child is able to read new words by the method of combining sounds he has previously encountered. One has to begin with monosyllabic words at first, such as 'the' or 'and', which can then be built upon to form other words, such as 'then', 'there', 'land' and 'hand'.

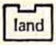
Protagonists of the 'whole word' method submit that before a child can possibly begin to learn to read he must be able to discriminate betweeen different written shapes and between different sounds. It is the combination or rather the association of these sounds with specific written symbols which enables a child to learn to read. By presenting whole words of different lengths, shapes and sounds the child is able to discriminate more easily than with words which are similar. For example, in the *Janet and John* series (10) words like 'aeroplane' and 'mother' are introduced very early. This is because such words with their particular shape are more easily discriminated than (say) 'there', 'then', or 'land', 'hand'. If one outlines the shape of these words, then the reasoning appears on Gestalt principles to be quite valid,

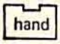
for example, 



compared with 

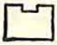


and 



since it is the meaningfulness of the whole perceptual structure which is important.

A weakness of this method would appear to be the difficulty of transfer or generalisation. This question will be dealt with more fully in a later chapter, but in connection with reading the problems are obvious. If a child is taught to read merely by recognising the whole shape of the word two difficulties immediately present themselves. Firstly, the child would have to be able to remember as many shapes as he would words, and also remember that similar shapes at times mean different words or have different sounds. For example, the

shape 

could represent either 'land' or 'hand', and the reader will be able to find innumerable other examples. This means that the child would require some other information in order to discriminate between the sounds of words of similar shape. To the experienced reader this perhaps presents no difficulty as the sense in general indicates the meaning of specific words. To the child learning to read these other cues are not available, and this is perhaps one reason why such a child seems to make apparently 'wild' guesses at words. Those teachers who have taught reading, especially to children who experience difficulty, will no doubt recall the numerous occasions when a child who cannot 'remember' a word apparently uses trial and error to select the correct one.

Secondly, this 'whole word' method does not appear to permit children to transfer their knowledge or to generalise from one word to another. If he learns the shape of the complete word then the individual letters and sounds, of which there are a limited number, would appear to have no value to the child, and he will therefore be unable to build up words with which he is not familiar by the combination of these discrete elements and sounds. In order to overcome these difficulties some teachers are using a combination of the 'whole word' and the phonic methods. Initially children start by learning the shape of the whole word and after some basic vocabulary has been established there is a transfer to phonics. This would appear to indicate a weakness in both methods, and whether a compromise is the solution must be open to question.

The instigators of the 'initial teaching alphabet' (i.t.a.) do not consider that a compromise is the solution, for they have produced a revolutionary reading scheme. They are convinced that the most difficult problem in getting children to read is for them to learn our rather irregular and inconsistent alphabetical spelling. To overcome this a new alphabet has been devised by Sir James Pitman, called the 'initial teaching alphabet', consisting of forty-three characters which constitute a regular and constant phonetic system. Children are taught to read using these limited sounds and characters and then they transfer to traditional orthography at a later stage. For further information the reader should refer to J. A. Downing's *The i.t.a. Reading Experiment* (11).

Another direct application of Gestalt psychology to learning in school is the use of structural apparatus for the teaching of mathematics as devised by Catherine Stern (12), C. Gattegno (13), and Z. P. Dienes (14). The idea behind this type of apparatus is that children perceive the pattern of number arrangements as a meaningful whole. This perceptual learning, which evolves from the child's handling of the actual apparatus and from his physical experience of the relationship between quantities, becomes a mental activity in its final stages. A vital part of this type of learning is the experience gained by usage, and unless teachers experiment with this type of apparatus its advantages and disadvantages remain at an academic level only. Success will depend upon a wide variety of unstructured experiences gradually leading through structured activity to the necessary mental constructions required for mathematical thinking.

The next relationship to be considered is the application of insightful learning to problem solving in the classroom situation. In Gestalt terms Wertheimer and Köhler would seem to suggest that problem solving or learning is non-verbal; the learner suddenly discovers the solution to the problem by insight when he is aware of the essential relationships. Previous discussion in this chapter has suggested that past experience is vital in learning, as indicated by the work of Birch (7) and more especially of Harlow (8). In any case not all learning is necessarily of the problem solving variety. There are many other things that children have to learn in our schools, some of which are dismissed today as an element in mere rote or mechanical learning and which play little part in our progressive educational reforms. The discovery method sets out to provide children with a series of structural problems for them to solve. This would appear to establish a hierarchy of principles to be learnt to enable the child to formulate the first principle into a new principle for the solution of the next stage. R. M. Gagné lists eight types of learning from simple signal learning to problem solving. For problem solving he lists four conditions. Firstly, the learner must have a goal or, as he says,

> 'The learner must be able to identify the essential features of the responses that will be the solution before he arrives at it' (9; p. 56).

Secondly, Gagné states that the learner must be able to recall relevant principles previously learnt; and, thirdly, that the recalled principles are then combined to form a new principle. Concerning the way in which this is achieved very little is known, but it does lead to his fourth stage where the solution is arrived at suddenly as if by insight. As he writes in conclusion,

> 'Problem solving results in the acquisition of new ideas that multiply the applicability of principles previously learned. As is the case with other forms of learning, its occurrence is founded on these previously learned capabilities; it does not take place "in a vacuum" devoid

of content knowledge. The major condition for encouraging the learner to think is to ensure he has something to think about. Learning by problem solving leads to new capabilities for further thinking. Included among these are not only the "higher order" principles we have emphasized here, but also "sets" and "strategies" that serve to determine the direction of thinking and therefore to productiveness' (9; p. 57).

In the classroom situation then the teacher must ensure that the children's past experience is known and utilised. Children are very often quite bemused in the classroom by what they are expected to attempt because the previous steps have never been taught or established. There seem to be three requirements for the establishment of a successful learning situation, namely,

1. The child must be able to recall all the relevant information he has previously learnt as and when required.

2. Not only must he be able to recall this information but he must be able also to relate these units of knowledge to one another and to apply them to the new principles he is attempting to understand.

3. To facilitate these processes it would appear that some verbal instruction is essential; and whether this is directed by the teacher or read by the pupil will vary with different circumstances. Nevertheless, as an aid to this type of learning, verbalisation has an important function.

But, when everything has been said in support of insightful learning, it cannot be 'a prototype' for a great deal of the learning that human beings normally undertake. It may well occur when we are learning by solving problems, but it is a fact that there are very many things we learn which are not themselves in the nature of problems, such as data, laws, principles and propositions (9; p. 17).

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Chapter 4

Transfer of Learning

An important assumption made in all education is that we expect children to transfer what they learn from one subject to another, and from what they learn in school to their activity out of school. Traditionally education developed in order to prepare a person for his or her role in later life and this is still important today. Teachers expect and hope that what they teach in their subject will prove of benefit to the child when studying another subject. To take a simple example, a mathematics teacher will hope that the mathematics acquired by the learner will be useful to him when studying a science, such as chemistry or physics. This is referred to as lateral transfer. Also a teacher in the infant school who teaches a child to read expects him to be to use this skill in all other subjects throughout his later school life. This is referred to as a vertical transfer. Children in secondary schools expect that much of what is taught them should be of value when they leave school. This naturally does not mean that they should be taught how to cope with each individual problem they might have to deal with in later life, as this would be an impossible task. Nevertheless they should be taught the basic principles from which they will be able to transfer their knowledge to the problems they are likely to meet.

Traditional classical education which consisted mainly of Latin, Greek and mathematics was firmly based on the premise that these subjects encouraged the development of memory, clear thinking and reasoning. This was supported by the Faculty theory of psychology which held that the mind consisted of separate, discrete faculties or powers, and that by the exercise of these the mind's ability to reason, think and remember was strengthened. This approach is somewhat similar to the belief that, as correct exercises strengthened the muscles of the body, so also the correct exercising of the mind would strengthen the necessary mental 'faculties'. This theory dominated educational practice until the beginning of the twentieth century when it was challenged by psychologists such as W. James, R. Woodworth and E. L. Thorndike.

It was Thorndike and Woodworth who emphasised that there would be no transfer unless there were identical elements in both the old and new learning (1). This theory of Identical Elements played an important part in the gradual move away from the old traditional education to the newer progressive methods, and has been a greater influence in the United States than in this country where we have tended to retain formal education in a large number of our secondary schools. This theory, held by the school of psychologists known as the Associationists (see Chapter 1), came under attack as a result of the work of C. H. Judd (1908) (2) who saw that an important condition for transfer was the ability of the learner to generalise from his experience by the abstraction of underlying principles. This became known as the theory of generalisation and has a similarity to the Gestalt idea of insight, whereby the learner holds a global view of his experience. This theory would suggest that it is possible to teach students to transfer by getting them to think about the principles involved from which they will be able to generalise.

These then were the early theories and it must be noted that they all accepted that transfer did take place. Many will remember learning Latin at school either 'because it was good for the development of the mind' (Faculty theory), or 'because it helped one to learn French or English' (Identical Elements theory). Whatever truth there might be in these theories, it would be agreed that there are many other factors involved before one could say whether and why transfer has occurred. These factors might include a like or dislike of different teachers, success or failure in the specific subjects concerned, happiness or unhappiness in school or at home, and numerous others which tend to complicate the issue. Transfer certainly does take place and we shall consider briefly some of the theoretical discussions and then see how we can apply the theories to classroom practices.

There are two principles of transfer, namely:

1. *Positive transfer:* what is learnt in one situation may help one's performance in another situation.
2. *Negative transfer:* what is learnt in one situation may hinder or inhibit one's performance in another situation.

In other words, positive transfer has taken place when something previously learnt benefits learning and, conversely, negative transfer occurs when something previously learnt hinders new learning. There are numerous examples of negative transfer in every day life, a common one occurring when a person transfers from driving a car with a clutch and gear lever to a car with automatic transmission. The driver experiences difficulty in transferring to the change in using one foot only instead of both feet. A common example in the classroom is found in Junior schools, when frequently a change of teacher means perhaps a change of writing style, and children often find themselves in trouble because they are unable to transfer to a different way of forming certain letters. In basic arithmetical processes a similar state sometimes arises, where different methods of multiplication or subtraction might be introduced by different teachers.

Transfer, then, is a part of our lives and experiments have been conducted to measure the amount of transfer. The most common form of experimental design is as follows:

Experimental Group:	Learn Task 1	Learn Task 2	Tested on Task 2
Control Group:	Rest	Learn Task 2	Tested on Task 2

The experimental group learns Task 1, then learns Task 2, while the control group learns Task 2 only; both groups are tested on Task 2. Positive transfer is said to have taken place from Task 1 to Task 2 if the experimental group is more successful than the control group. If, however, the results are reversed and the control group is more successful than the experimental group, then negative transfer is said to have taken place because the learning of Task 1 would appear to have inhibited the learning of Task 2. It is assumed that both groups are equivalent in respect of age, past experience and so on, that is, that we control as many varibles as possible.

The other common form of experimental design is summarised as follows:

Experimental Group:	Learn Task 1	Learn Task 2	Tested on Task 1
Control Group:	Learn Task 1	Rest	Tested on Task 1

A comparison is made between the results of the final Task 1. If the experimental group do better, then it would suggest that Task 2 has helped the transfer of learning; but if the control group are more successful when examined on Task 1, then it would suggest that Task 2 has inhibited transfer. These two simple experimental designs give rise to what is known as proactive and retroactive inhibition. In the first experiment, if Task 1 prevents the learning of Task 2, then proactive inhibition has occurred; and, similarly, in the second experiment, if Task 2 prevents the learning of Task 1, then retroactive inhibition has taken place. Use of this type of experiment also forms the basis of investigation into memory, and the problems of transfer of learning and memory are to some extent the same.

A comprehensive study of the transfer of learning has been provided by H. Ellis (1965) (3). For our present purpose, however, we need to concern ourselves with the two major schools of thought, namely those of identical elements and generalisation. Both these theories appear reasonable if we select the right example. A child learning to spell will certainly achieve transfer if presented with words with common elements such as fr-*ight*, br-*ight*, l-*ight*. Supporters of generalisation suggest that a child who has learnt the principles of addition is able to transfer this to multiplication. It would appear that both theories are applicable. It could be said that in the example of spelling the child generalises using the common element *ight* as used in this case; in the learning of multiplication it should be the common element of addition which is transferred. If we apply the principle of transfer to the simple learning situation, it would appear that the following general conclusion may be made:

1. Similar responses to similar stimuli result in positive transfer.
2. Similar responses to different stimuli result in positive transfer.
3. Different responses to similar stimuli result in negative transfer.
4. The amount of transfer depends upon the similarity of the stimulus.
5. Whether positive or negative transfer occurs will depend upon the similarity of the responses.

We have not as yet considered the state of the learner, but before we do so it is necessary to look at the very important contribution to the problem of transfer by H. F. Harlow (1949) (4). One of the results of his study was to highlight the fact that whenever positive transfer occurs we are learning how to learn. This learning how to learn is brought about by the formation of *learning sets*. As Harlow states:

> 'The learning of primary importance to the primates at least is the formation of learning sets; it is the learning how to learn efficiently in the situations the animal frequently encounters. This learning to learn transforms the organism from a creature that adapts to an environment by trial and error to one that adapts by seeming hypothesis and insight' (4).

In his experiment Harlow used eight naïve monkeys, 'naïve' here implying animals which had not been exposed to any previous experiments. The monkeys were set a number of discrimination problems – 344 in all. Each monkey was seated behind a tray on which were two objects different in size, shape or colour. A reward of a raisin was placed under one, never under the other. If the two objects or stimuli were a cube and a solid triangle, the raisin would always be under (say) the cube. The positions of the two stimuli were randomised and the monkey had to learn which of the two stimuli hid the reward. After mastering this discrimination problem he was presented with another. The new problem might be with a small cube and a large cube. A succession of discrimination problems was given and the monkeys became more and more efficient, and after hundreds of practice trials learnt to solve the discrimination problem immediately. On each of the first 32 problems the monkeys were given 50 practice trials and on each of the remainder of the problems they received from 6 to 11 practice trials. The results showed that there was a gradual improvement over the first 6 trials which was maintained over the other 44 trials; but by the time the monkeys were working on problems 100 to 200 they were correct about 85 per cent of the time, and for the last 56 problems they achieved 95 per cent success.

It is important to remember that each problem on the first trial could only be either correct or incorrect, and it was the second trial which indicated the acquisition of the learning. If he selected the correct stimulus the first time the monkey had to decide to stay with this choice; otherwise, if he were wrong on the first choice he had to switch to the second stimulus on the second trial. If the reward was not under one stimulus then it was immediately found under the other. As Harlow explains it, the monkeys had acquired a learning set; they had learnt how to learn and solved this problem. The problem was then reversed and the stimulus which previously had been correct was now incorrect. The monkeys immediately learnt to switch their choice, evidencing positive transfer from one problem to the other, or in Harlow's words.

> 'the discrimination reversal learning set was formed more rapidly than the previously acquired discrimination learning set. The explanation probably lies in the nature of the transfer of training from the discrimination learning to the discrimination reversal problems' (4).

These experiments were repeated with children with similar results. In fact the children were superior to the monkeys on the reversal discrimination problems and this would also suggest the acquisition of learning sets and the positive transfer of abilities rather than a specific bond of knowledge. There did not appear to be any difference between the actual brain mechanisms of the monkeys and children apart from the superior speed of the latter with the reversal discrimination problems.

What has actually happened is that there has been an improvement in the subject's ability to solve the individual problem. This is really a development of some higher-order thinking. In standard discrimination problems the subject is rewarded if he chooses the correct stimulus only, say a red cube, whereas with Harlow the reinforcement is applicable to the reasoning to stay with the correct choice, if not then to switch. This is where the importance of this work lies. This ability to apply the learning acquired in the learning set is in reality the ability to abstract the general principles – stay with the correct choice; if not, switch – and apply it to similar problems. An interesting side-issue remarked upon by Harlow was the formation of social and emotional sets by the monkeys. Remember that these animals were wild when first attempting the experiments but at the end of the series they had become socially adaptable and had learnt to behave favourably towards one another. This acquisition of a *social* learning set has clearly some significance for school life.

Prior to this work done by Harlow L. B. Ward (1937) (5) investigated transfer by presenting to selected subjects successive lists of twelve nonsense syllables to learn each day. Thirty-eight trials were required for the first list, only twenty trials were required after six lists, and after fifteen lists fourteen trials were required. There was no connection between the nonsense syllables but the subjects had in fact learnt how to learn the lists and it is important to note the rapid improvement during the first six lists.

Although Harlow used some children as subjects it was C. P. Duncan (1960) (6) who explored some of the characteristics of human learning. His subjects, forty men and women undergraduates, learnt a series of ten tasks of paired associates each containing thirteen stimulus-response situations. Details of the experiment will not be included here; what does concern us is the analysis of the results. The greatest improvement occurred during the first few tasks with little further improvement after the sixth or seventh task. Duncan selected out the ten fastest learners and the ten slowest learners on the basis of their total correct responses on Task 1.

The slow learners were those in the bottom 25 per cent, and the fast learners were those in the top 25 per cent. The figure is extracted from Duncan's paper and it is important to note that the difference performance between the two sets of subjects is markedly at variance on the first task.

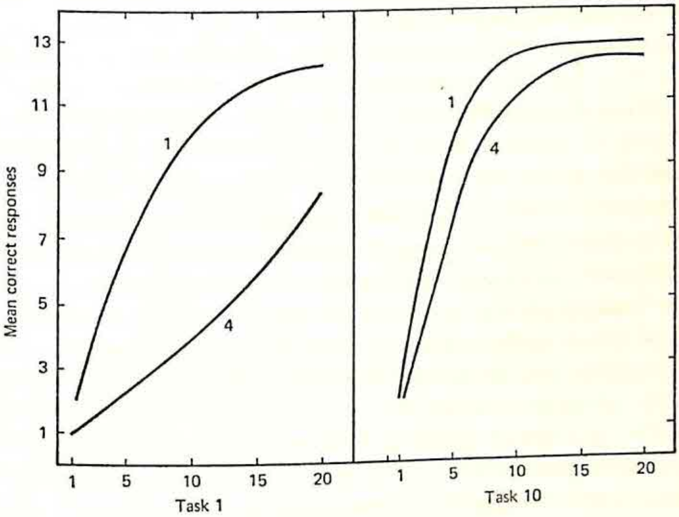

Figure 18

It should also be noted that the difference between the fast and slow learners is very great on the first task, and that the learning curve for the fast learners is negatively accelerated whilst the curve for the slow learners is positively accelerated. This indicates that the fast learners improve rapidly during the first few trials whereas the slow learners begin to improve only after a number of trials.

On the tenth task the learning curves for both the fast and slow learners are negatively accelerated and there is only a slight difference in performance between both groups. From these results, as Duncan says, 'It was shown that slow learning subjects, those in the bottom quartile, benefit enormously from learning to learn, though it was not proved that they benefit more than fast learning subjects, those in the top quartile' (6). It would appear that by providing slow-learning children with more practice or more experience at specific learning tasks their performance will improve tremendously and will not be so markedly different from the quicker learners. Duncan (1960) (7) investigated the aspect of learning to learn by comparing the difference on two different types of task. One was a simple paired-associate task and the other a response-discovery task which required greater choice in the behaviour of the subject. The result of this study suggested that there was a greater rapid impovement and marked positive transfer when subjects were dealing with the more complicated response-discovery tasks.

From the investigations of Harlow and Duncan *et al.* it would appear that there is an improvement in the ability to learn, which results from the practice of a specific kind of learning. This must be important in our teaching of children who require considerable practice on new problems, since learning to learn appears to be acquired with numerous practice trials on related problems.

Before discussing the degree of transfer achieved by using different teaching methods we have to consider individual characteristics of the learner himself such as maturation, drive, curiosity, anxiety, attention and so on. In the experimental situation the subject is usually a little anxious, but quite attentive and often motivated either by curiosity or in some cases by financial reward. Unfortunately the normal class includes children who are anxious to succeed, as well as those who are inattentive and poorly motivated. In the following discussion about transfer and different teaching methods it must be remembered that the individual differences will play an important part and any theory of 'learning to learn' is not necessarily the panacea for successful education.

The research concerning the individual learner characteristics and their influence on transfer tends to suggest that with higher intelligence greater transfer is to be expected. Anxiety, which is a chronic complex state, with dread or apprehension as its most prominent component, is a motivational variable and as such it also has an effect upon performance; a fact which was investigated by K. M. Spence (1964) (8). The implication from this study for classroom practice seems to be that while anxiety appears to assist performances in simple learning situations it has the opposite effect with more complex learning situations. E. L. Gaier (1952) (9) was interested in finding out the effect of anxiety on these two different types of learning. One test which he gave to students relied mainly upon memory, while the other required the more complex behaviour involving the abstraction of principles. His general findings were that students with a high level of anxiety performed better on tasks involving the recall of facts while students with a low anxiety level performed better on the more complex tasks. The importance of this finding for teachers is fairly obvious and care needs to be taken not to raise the level of anxiety too high in the classroom especially when new concepts are to be introduced.

One example of complex behaviour in the classroom is problem solving, which some prefer to consider as a special case of transfer and regard it as a method of teaching children to think. A solution to a problem is found when the learner achieves the set goal, and it may be arrived at either by trial and error (Thorndike's cat), by some form of analysis of like problems, by insight (Köhler's apes) or by the application of past experience. If we accept that solution by trial and error is in a separate category and insightful solving is the result of a learning set (Harlow), then the transfer of principles acquired previously in similar situations is essential for success. Most studies of problem solving do not deal with the past experience of the subject simply because it is too difficult really to ascertain what this has been. The emphasis has been upon negative transfer, often called inhibition or fixation, and fixation on some unproductive behaviour during problem solving will usually result in negative transfer. This fixation highlights perhaps the most important aspect in considering how far past experiences influence present behaviour or learning. Much learning is simply the transfer of old learning to a new situation.

It would appear that we tend to transfer established methods of solving problems even if they are not particularly efficient. A. S. Luchins (1942) (10) demonstrated this in the following experiment, in which he gave a selected number of subjects this problem to solve. Given a 3-quart jar, a 21-quart jar and a 127-quart jar, devise the smallest number of moves required to measure out exactly 100 quarts. Six problems were set similar to this in which the solution required the efficient use of all three jars. For example, to obtain 100 quarts the correct procedure is first to subtract 21 quarts from 127 quarts, leaving 106 quarts; then to subtract two lots of 3 quarts. The ensuing problems could be more efficiently solved by using two measures only, although it was possible to solve them by using all three measures. The majority of subjects influenced by their past experience, persisted in using three measures.

A variation of this effect of fixation was investigated by Ackerman and Lewin (1958) (11). Two groups of 11–12-year-old children, matched in intelligence, were trained to solve water jar problems similar to those posed by Luchins. One group was shown two ways of solving the problems and the other group one only. The children were then set to solve similar problems and different problems. The group who had been taught two ways continued longer and produced greater variety of solutions. Thus, if we wish to develop fluidity of thought and some originality of operation in our pupils, it would seem to be desirable to provide as wide a variety of examples, tasks and solutions as possible.

K. Duncker (1945) (12) illustrated how past experience of functional use of objects inhibited transfer. In one experiment the subjects were required to fix three small candles on a door. For one group there were scattered on the table the materials required, such as tacks, matches, matchboxes or similar small boxes, and some candles as well as some irrelevant objects. For the other group the tacks were placed inside one box, the candles in another and the matches in a third. The first group who received the boxes empty all solved the problem, whereas of the second group just under half succeeded. The solution was a reasonably simple one – the tacks were used to fix the boxes to the wall, and then the matches were used to light the candles to melt some wax so that the candles would be held upright. Although very small numbers of subjects were used, similar experiments have demonstrated that fixation often results in negative transfer. It would appear that the subjects who were given the boxes full of items tended to regard the boxes as containers only. This raises the question of the influence of mediating responses which can be verbal or non-verbal. In this experiment they were non-verbal and the subject was influenced to regard the boxes as containers or as possible platforms. Full discussion of this topic and further experiments may be found in 'Reasoning in Humans' by N. Maier (13).

However one considers the problem of transfer, past experience and the necessity for some cues or direction, either verbal or non-verbal, are very important. As teachers we need to carry out a pretty careful task analysis in order to make sure of an appropriate sequence of movements, otherwise children will be attempting to acquire new learning by mere trial and error, somewhat similar to Thorndike's cats in the puzzle box. We must also be concerned with the elimination of the causes of negative transfer and this requires the elimination also of incorrect responses.

When we consider transfer in relation to teaching practices we find that, broadly speaking, teachers tend to divide into the traditionalists and the progressives. The traditionalists incline to the use of formal methods, and the progressives informal methods. In the traditional formal teaching, positive transfer is believed to be effected through the study of specific subjects, such as mathematics and Latin, which are thought to aid reasoning and memory by 'disciplining' the mind. The transfer is assumed to be automatic, and much formal teaching is still based on the belief that orderly presentation and logical development in one subject will transfer to another. With the 'progressive' or informal approach, however, reliance on positive transfer would appear to depend more on the abstraction of general principles discovered by the children in their activities and then applied to relevant tasks. Progressive education makes use of guided discovery in which the learner receives some assistance from the teacher, which might be in the nature of mediating responses of the verbal kind which, whilst not telling the pupil precisely what to do, nevertheless helps to direct his attention or 'learning set'. B. Kersh and M. Wittrock (1962) (14) suggest that 'Guided discovery seems to offer a happy medium between independent discovery and highly directed learning', and that:

> 'For the goal of teaching specific aspects of subject matter – aspects which could be either memorised or discovered – it is clear that the process which was described as directed learning is most efficient. Generally speaking, a teacher should not employ highly directed techniques if she wishes to develop long-term retention and transfer effects.'

E. Hilgard *et al.* (1953) (15) illustrated the importance of understanding the principles of guided discovery learning in the following manner. A number of college students were required to learn the solution to the card trick problem in which the cards have to be so arranged that when dealt they appear in a set order. The first group were shown the formulae whereby the arrangement of the cards could be understood, whilst the second group were allowed merely to memorise the solution. Both groups were then set new but related problems. As one might expect, the first group showed more evidence of positive transfer and were quicker in obtaining a solution. This is also an example of guided discovery in which the teacher provides the cues for the learner. Another example of abstracting the principle was demonstrated by G. Hendrickson and W. Schroeder (1941) (16) in an experiment which was really a development of Judd's demonstration of generalisation and transfer (2). Hendrickson and Schroeder selected ninety 14-year-old boys with above-average intelligence and separated them into three equal groups. Groups A and B were given a written explanation of the principles of refraction to study until learnt. This explanation, with an accompanying diagram, showed that an object under water is not in the place where it appears to be. Group B's explanation contained an extra sentence, however, which stated that the deeper the water the further the distance of the object from its apparent position.

Group C were provided with no explanation at all. All three groups were then set the task of firing with a repeater air-gun at a target six inches below the surface. This practice continued until they each hit the target three times in succession, and when this was achieved the target was raised four inches and the experiment repeated. In both trials B required fewest shots and Group C the most. The success of Group B was clearly a result of their understanding of the principles involved, and as the other groups came to understand those principles no doubt their scores would improve. Thus, a greater degree of transfer would appear to occur if a number of tasks are provided, using the unit to be learnt in a variety of ways and with understanding. But how can one ensure that such understanding takes place? In any teaching situation some consideration should be given to the following general rules:

1. Ascertain as far as possible the past experience of the children in relation to the new material you intend to teach. This will probably vary considerably and your approach will have to be modified for different groups of children. Thus, if one wished to introduce a class to the division of fractions, this would be pointless unless they had

previously dealt with and understood the division of whole numbers and the multiplication of fractions.

2. Provide a wide variety of examples and adequate experience. Learning-set theory implies that learning how to learn is acquired after much practice on related problems.

3. Careful instruction on the basic skills is extremely important. Any misunderstanding will not only prevent positive transfer but actively produce negative transfer which is cumulative in effect.

4. Provide the necessary cues when required. Mediational processes are important and the teacher must direct the children's attention to the correct responses either by verbal or by non-verbal methods. The elimination of incorrect responses is as important as the encouragement of correct responses. Children should be helped to understand why certain responses are correct.

5. When setting tasks on the material learnt, try and ensure that these are as similar as possible to the learning situation.

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Chapter 5

Physiological Processes Involved in Learning

Up to the present we have concerned ourselves with external processes in learning which are visible to the teacher and observer, but there are also vital internal processes taking place which are not directly observable. These activities occur in the central nervous system (CNS), consisting of the brain and spinal cord, and the success of all learning is largely dependent upon the activity of this part of the human organism.

For a child to learn, whatever the method or learning situation, three activities must take place:

1. The organism (the child) must seek out and take in information from the outside world or environment, known as the stimulus (S).
2. The organism (the child) must make some response (R).
3. The organism (the child) must be able to alter, if necessary, the relationship between the information coming in (S) and the response (R).

How does the brain acquire its information? At the physiological level it must do so through the sensory organs, namely, the eyes, ears, nose, tongue and by touch.

In Fig. 19 it will be seen that the information arrives at the various

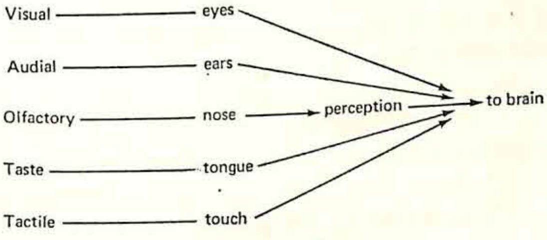

Figure 19

reception organs in different forms of energy; and in the teaching situation the most important sources of information are those of vision, hearing and touch. When teaching we do not rely so much on taste and smell, apart from such specialist areas as domestic science.

As teachers we impart most of our information so as to reach the child through his ears, eyes and surface reception, or touch. This information arrives at the body in different forms and has to be translated into a common language or code so that the brain can deal with it as quickly, efficiently and accurately as possible. Not only is this so but, paradoxically, a major portion of it has to be discarded or rejected. If one considers the amount of information flowing into the human brain at any one moment via all the reception organs, one appreciates how selective the brain must be. Consider for a moment what is happening while you are reading this chapter. There are probably noises inside the room such as a clock ticking, chairs scraping, people shifting in their seats, the sound of traffic outside, the wind blowing, a transistor radio playing and so on. There may also be a continual change in the pattern of light, shadows forming as your eyes change in position; you may be moving in your chair, crossing your legs, or wiggling your toes – all these and numerous other activities are passing on information through the CNS to the brain. Some never reach the brain and are dealt with or inhibited before they can arrive at the control centres.

THE CODING OF THE STIMULI

Sensations reach the body in the forms of different energy and the fundamental question is the manner in which this information is coded. The stimuli come in various physical forms such as light waves, sound waves, pressure, heat and so forth, but the important point to note is that it is not the type of stimuli which is vital, but rather the receptors and nerves activated by the stimuli. For example, if you close your eyes you will see some pattern of light; now if you press on your closed eyelids the pattern will change only because the optic nerves have been stimulated. The visual sensation is experienced, not because of light waves, but because the nerves stimulated are those connected with pathways to the part of the brain which controls vision. In a similar manner activation of the auditory nerve produces auditory sensations because the energy is transferred through the neural pathways leading to the part of the brain dealing with this particular type of information (see Fig. 20).

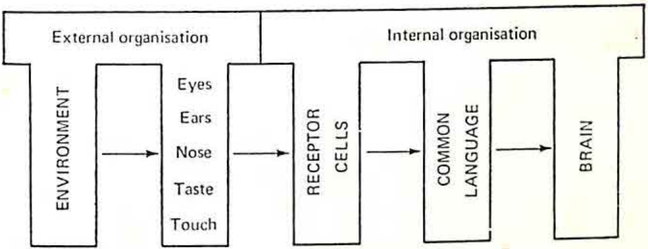

Figure 20

Not all receptor systems have actual receptor cells, but in the eye there are the rods and cones of the retina, whilst in the cochlea of the ear there are the hair cells. The receptor cells when stimulated produce an electrical activity which is transmitted through the CNS to the relevant part of the brain. This transmission has to pass along nerves which connect the outer area of the body to the deeper centres of the brain, and during this passage opportunities exist for the impulse to be inhibited or stopped as well as being passed on. At various stages between *neurons*, as these nerve cells are called, there exist gaps known as *synapses* where the electrical energy results in chemical changes which carry the message to the next neuron. For more detailed analysis the reader is recommended to read D. O. Hebb's *The Organization of Behaviour* (1).

The neuron is the basis of our cerebral activity (or cerebration), and although neurons vary in size and shape and, to some degree, in the type of activity they perform, their basic design is fairly constant. A neuron is really a nerve cell complete with cell body and fibres, and all neurons, whatever their function, size or shape, consist of the cell body and the fibrous axon and dendrites. The cell body contains the *soma* or *nucleus* which is responsible for the organisation and life of the cell. The shorter fibres which extend from the cell body are known as the *dendrites*, whose function it is to receive messages from other neurons, while the *axon* – usually a much longer fibre – conveys the message away from the cell (see Fig. 21).

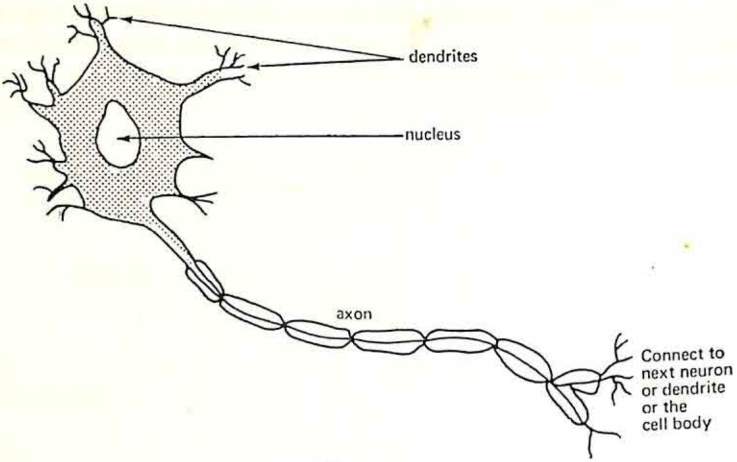

Figure 21

The cell body itself is often less than one-tenth of a millimetre in diameter and its fibres are considerably smaller. The length of the axon in the human body, however, may be up to a metre; and in other mammals such as the giraffe it may be considerably longer. In the mature human brain there are up to 10,000 million neurons, and this is one of the reasons why the actual mechanics of the transmission is to some extent speculative, and we are perhaps only at the 'steam engine' stage of development in our understanding of the CNS. What we do know is that the neuron receives messages from other neurons via its dendrites and in turn transmits to other neurons via its axon. The energy which actuates this transmission is electrical, and this activity is transferred from one nerve cell to another at the *synapse*, which is the point at which the axon makes contact with another nerve cell. The only method whereby neurons affect each other is by means of this *synaptic interaction*.

Neurons, as do all other cells, participate in a number of physical and chemical processes, but the essential characteristic of the neuron is its ability to generate sufficient electrical voltage to be measured. When the nerve is resting, the voltage across the membrane – that is, the boundary between the inside and the outside of the cell body – is one-tenth of a volt, but on activation a change in voltage develops which travels down the axon. When it arrives at the end of the latter it causes certain chemical changes which are transmitted to the receiving areas of the next cell body. Transmission across the synapses appears to be chemically mediated, for when the impulse reaches the end of the axon a chemical transmitter substance is released which bridges the synaptic gap and stimulates (or inhibits) the fibre on the other side of the gap (see Fig. 22).

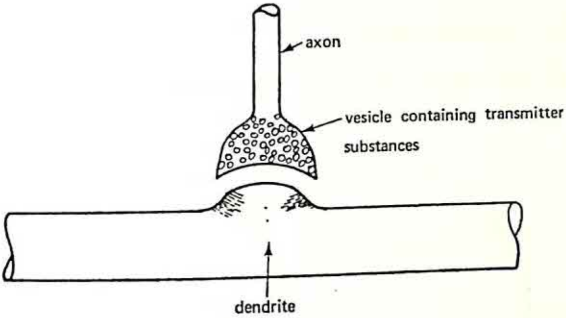

Figure 22

After the cell has fired there is a fleeting period of one five-hundredth of a second during which it cannot be stimulated. The decision made by a neuron whether to fire or not depends upon the number of synaptic transmissions being made. If these are strong enough to bring about a sufficient change in the potential of the membrane, then the cell will fire. If this change is insufficient the cell will not fire. This is known as the 'all or nothing' principle and is very often compared to the firing of a rifle. If one squeezes the trigger sufficiently to exert adequate pressure, then the bullet is fired and the velocity of the bullet has no relationship to the strength of the squeeze once it has crossed the threshold of pressure required for firing. So it is with each neuron which has a threshold excitability, and if the stimulus is too weak it will not fire nor pass the message on. As each neuron is the recipient of hundreds of axons each capable of bearing a certain piece of information, there is the possibility of very complicated messages being passed on to the brain.

Some neurons can inhibit the transmission of information so that some messages do not reach the brain for action. One might also note that as the neuron works on an 'all or nothing' principle the difference between a strong stimulus and a weak stimulus can be relayed only by the speed of the impulses and not the size. This then very simply is the transmission of information to the brain by the *afferent* nerves, and a similar action takes place when the brain sends messages along the *efferent* nerves to the motor muscles after it has decided what action to take. For further information on the problem of cell communication reference may be made to 'How Cells Communicate' by B. Katz (2).

THE BRAIN MECHANISM

In Fig. 23 reference is made to the cortex and it is indicated that different parts of the cortex have different responsibilities. This is only part of the process and it is necessary at this stage to consider the mechanism of the brain more fully. The human brain is the principal part of the CNS encased within the skull; as it leaves the skull it becomes the spinal cord which has two principal functions. The first is to act as the conductor of impulses to and from the brain, and the other as an organ which deals with reflex actions such as scratching, the withdrawal of the hand when touching anything hot, and so on. Important as this type of behaviour is to our welfare, it is the brain as it plays a vital part in our complex human activities such as learning, thinking and speaking which is of far greater interest to us. An interesting and informative book on the whole subject is that by R. F. Thompson (3; p. 82).

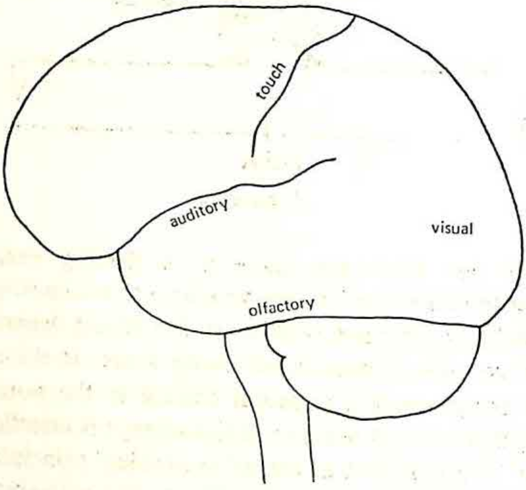

Figure 23: The cerebral cortex and its functions.

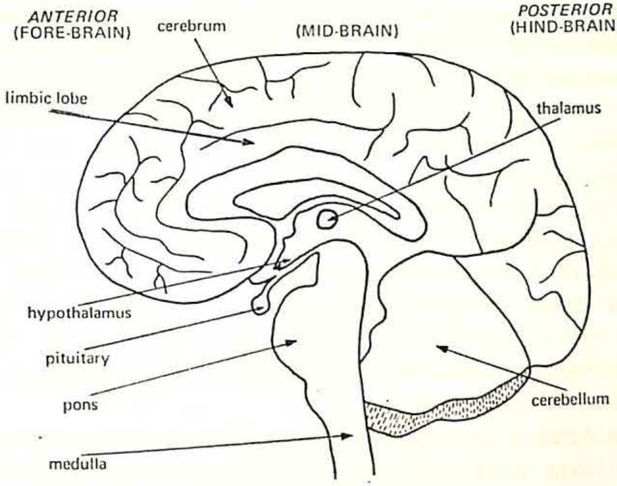

Figure 24

The brain (see Fig. 24) can be divided into three main areas as follows:

A. *Fore-brain*	B. *Mid-brain*	C. *Hind-brain*
1. Cerebrum	1. Reticular System	1. Pons
2. Thalamus	2. Roof (tectum)	2. Medulla
3. Limbic System	3. Floor (tegmentum)	3. Cerebellum.

A. *The Fore-brain*

This is the major portion of the brain in humans and mammals which, although it is the last part to develop, plays a vital part in our complex behavioural patterns. The *cerebrum*, which consists of the two cerebral hemispheres, is covered by six layers of cells and fibres known as the cerebral cortex, usually referred to as the cortex or neocortex. Fishes, for example, have no cortex, but in the ascent of the phylogenetic scale the cortex has evolved, became elaborated and enlarged. In fact, in human beings it has so developed that it has become wrinkled, creased and folded to fit into the bony structure of the skull. It is often compared to the skin of an orange which, when pinched between thumb and forefinger, falls into crevices and ridges. This is in fact what has occurred in the cortex which has two major ridges known as the *central fissure* and the *Sylvian fissure*. These foldings or ridges, with their many convolutions, actually increase the surface area of the cortex considerably.

In the cerebrum the 'grey matter', consisting mainly of neurons or nerve cells, is on the outside, while the 'white matter', namely the fibres covered with white myelin, is on the inside. The grey matter can, to some extent, be regarded as the final destination of the sensory input which we discussed earlier in this chapter. Up to 1950 it was widely accepted that the sensory input was relayed by a system, rather like a switchboard, to the motor areas via the association areas for action. K. S. Lashley (4) rather destroyed this conception of the actuation of the cortex when experimentally he severed the motor areas from the sensory areas by deep vertical cuts, and showed that there was no real impairment of the animal's behaviour. In fact, our actual knowledge of the integrative function of the so-called association areas is very limited.

The *thalamus* is an extremely complex structure situated just above the mid-brain, consisting of many nuclei grouped into three main areas: the *sensory relay nuclei,* the *association nuclei* and the *intrinsic nuclei.* It is in fact a kind of relay station and all the afferent systems which convey information to the brain do so through specific nuclei in the thalamus, apart from the olfactory (smell) system. These nuclei are the sensory relay nuclei. The association nuclei perform the same action by relaying information to the association areas of the cortex. The intrinsic nuclei appear to have a somewhat different function and have connections not only with the *reticular formation* but also with the *limbic system.*

The limbic system is really the core of the primitive or 'old' brain, and because of this it is mainly concerned with olfactory functions in lower species. In man this area is a complex system of pathways consisting of three divisions of which the *hypothalamus* only at present concerns us. The hypothalamus lies below the thalamus and acts in two ways – neural and glandular. The neural function operates by connecting with higher regions of the brain that are neither sensory nor motor; whilst the glandular function occurs by controlling the *pituitary gland*, which in turn controls the *endocrine glands* or ductless glands, so called because they secrete directly into the blood stream. The hypothalamus appears to have three main areas of influence; as well as integrating our emotional behaviour it is concerned with the homeostatic balance including body temperature, our feeding and drinking behaviour, and finally our sexual behaviour.

B. *The Mid-brain*

This is an extension of the brain stem which connects the fore-brain to the hind-brain and transmits impulses upwards and downwards. The *tectum*, or roof, contains important nuclei for the relaying of impulses from the auditory and visual systems, while the *tegmentum*, or floor, contains nuclei which control eye movement.

The *reticular formation* extends from the medulla, through the mid-brain, to the hypothalamus and thalamus. It is a mass of fibres (*reticulum* means network) running in all directions. It is divided into two sections, namely, the *descending reticular system* which consists of axons having motor functions, and the *ascending reticular activating system* (ARAS) having primarily sensory functions. This reticular formation, smaller than the little finger, is vital for our highest mental processes, such as abstract thinking and the focusing of attention. The ARAS has the responsibility of rousing the cortex; it does not relay any specific messages but learns by experience to select those messages of which it considers the cortex should be aware. A common example is the waking of a mother to the cry of a baby. By this selective function the reticular formation is recognised as a vital link in our reasoning ability.

C. *The Hind-brain*

This has three main divisions: the *pons*, the *medulla* and the *cerebellum*. The pons acts as a bridge to convey fibres from one side of the cerebellum to the other; it also contains ascending and descending bundles of fibres connecting the cortex and the spinal cord. The medulla (*oblongata*) is the first part of the brain stem next to the spinal cord, and as such it has a function similar to that of the pons containing bundles of ascending and descending fibres. It also contains vital centres for relaying sensory messages upwards to the fore-brain as well as nuclei concerned with heart-rate and breathing. The cerebellum, situated above the pons, is analogous to the cerebrum in structure in that it has two symmetrical halves; it is convoluted and has grey matter on the outside with underlying white matter. Its chief function appears to be the co-ordination of motor activity by blending the action of different groups of muscles. In order to achieve this there has to be considerable feedback.

THE STRUCTURE OF THE CEREBRUM

The cerebrum is divided into two symmetrical halves or hemispheres linked by the *corpus callosum*; the right-hand half controls the left-hand side of the body and vice versa. It is also divided up into four *lobes*, known as the *frontal* lobe, the *parietal* lobe, the *temporal* lobe and the *occipital* lobe (see Fig. 25). The frontal lobe, distinguished by its size in relation to the brain, has been the subject of much experimental work especially with animals. Situated in front of the central fissure, it has been attributed with intelligence, emotion and sensori-motor functions. Little is really known about this at present, but an authoritative book of reference is that edited by J. M. Warren and K. Akert (5) where the reader will find detailed reports of recent research. The parietal lobe behind the central fissure appears to be concerned with the sensations of touch, warmth, coolness and kinaesthetic sense. A portion of this area, especially in the left hemisphere, is associated with symbolic speech as also are the frontal and temporal lobes.

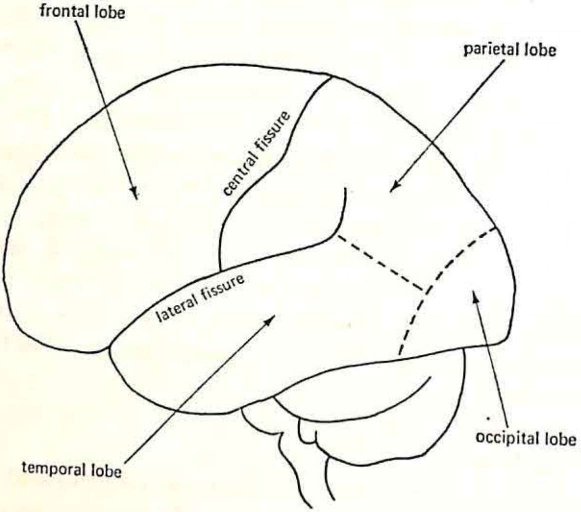

Figure 25

The occipital lobe situated at the base of the skull is the part of the cortex which appears to deal with visual input. One must remember that what is seen on the left is transmitted to the right occipital lobe and what is seen on the right goes to the left. The *temporal* lobe contains the primary area for the reception of sound. It is situated below and to the side of the lateral fissures and, although both lobes receive from each ear, the main input is from the opposite side. This area of the cortex is also connected with the visual perception of form or shape, and W. Penfield and L. Roberts (6) reported that stimulation of this area often resulted in the recall of vivid memories; this does not mean, however, that the temporal lobe is the centre of memory.

SUMMARY OF THE PHYSIOLOGICAL PROCESSES

1. In order to learn, one must take in information from the environment.
2. This information is obtained by specialised receptor organs, such as eyes, ears and nose, and transmitted by specialised receptor neurons.
3. The signal in each neuron results in certain electro-chemical changes at the synapse where neurons connect.
4. The messages are analysed and integrated where one nerve fibre connects with another, depending upon the specific channel used and the gap in time and space between impulses.
5. Not all sensory information travels direct to the cortex but some goes to reflex centres in the spinal cord.
6. The ascending reticular activating system (ARAS) appears to act as a control centre for the cortex both for the input and the output.
7. The output from the CNS is controlled by the input.
8. The connections between the nerve cells in the brain appear to be broadly similar to those in sensory and motor pathways.
9. Impulses are transmitted either through cranial nerves or the spinal cord to the appropriate muscles.
10. The actual processing of the information is still largely unexplained.

Just as the method of processing of information is unknown so also is the function of the large areas of the brain perhaps misleadingly known as the *association areas*, which make up the largest single area of the brain. Originally they were thought to transmit messages from the sensory to the motor regions, but this is now considered unlikely and it appears that they receive their own specific sensory input from the *intrinsic nuclei* of the thalamus, as compared with the sensory areas which receive impulses from the *extrinsic nuclei* of the thalamus. The association areas of the cortex are apparently secondary regions as they receive information or projections which have been transmitted from the extrinsic nuclei of the thalamus to the intrinsic nuclei and then projected to the association cortex.

These areas of the cortex are divided into two main regions, the *PTO association area* which comprises parts of the *p*arietal, *t*emporal and *o*ccipital lobes, and the frontal association area located in the frontal lobe. Damage to the PTO association area often results in speech defects; such as aphasia, which can be (*a*) auditory where one cannot comprehend speech, or (*b*) visual where the ability to read and comprehend written speech is impaired. Damage to the frontal association area has been considered to impair man's most complex intellectual achievements, but H. L. Teuber (7) demonstrated that marked intellectual deficiences did not show up on standardised intelligence tests. Other research indicates slight personality changes and some difficulty with sensori-motor skills, but at present it is not possible to ascribe specific responsibility to this region in the light of our present knowledge.

Whatever the exact roles of the various parts of the brain it is evident that they all require *feedback*, or information as to the success of their instructions, to the different parts of the body which enable the brain to send finer and finer signals. This feedback must come from the environment so that the brain can judge the success or failure of the responses made. Thus the brain needs to retain information of previous responses to similar stimuli in order to make these adjustments. This retention of past information has to be both immediate and long lasting, and it is the ability of the individual to recall past experiences and apply them to new circumstances that constitutes learning. This ability to recall is what we really mean when we talk about memory.

REMEMBERING AND FORGETTING

From our knowledge of the transmission of experience through the CNS, by electro-chemical changes, it would be logical to expect some permanent record of these experiences. This material which has been learnt, and these experiences which have been undergone, are recorded in the brain cells and this physical change is known as a *memory trace* or *engram*. David Wechsler (8) criticises this view of memory and states that there are no stored memories in this sense when he writes, 'It does not store or permanently record anything. Its essential function is to code and transmit information as needed.'

Whatever view one takes, whether one considers that remembering is a question of memory traces or that it is a function of learning, it is a matter with which teachers are vitally concerned. How much do we really remember? W. Penfield appears to indicate that all our experiences are stored away and that the problem is not one of forgetting or remembering but one of recall. Let us assume that we require the children we teach to remember the information we give them during the lesson and to be able to recall it as required. What are the processes involved? According to Metcalfe (9; p. 6) 'memory includes at least three stages: acquisition or registration; storing or retention; and recall or recognition'. During a history lesson, for example, certain facts are provided, and these are enlarged upon by discussion: this is the acquisition. The retention or storing of the information is by the action of the CNS as discussed earlier in this chapter, and the recall or recognition is conveyed by apt questioning or some set activity such as written work or diagrammatic representation.

How can we help children to remember? First of all let us consider pure rote memory or memorisation. Young children have to memorise their name, their address, etc.; as we grow older we memorise songs, formulae, dates, climatic conditions and so forth, and from these we are able to make specific forecasts, or set up a hypothesis and carry out certain logical thinking. Perhaps the memorisation is merely the learning of a poem, yet even this requires a certain programme or definite planning in this sequence: understanding, spacing and repetition. Learning or memorisation of a poem is greatly facilitated if the child fully understands its meaning; and this understanding is in its turn facilitated if the child is able to see the words of the poem and is not merely required to repeat them orally after hearing them. In this way, two senses will be used instead of one. By spacing we mean the division of the poem into meaningful units of suitable length which can be memorised one by one; but mere division line by line is often useless since the meaning is destroyed. Finally, in order that the item to be learnt may be transformed from short-term memory to long-term, it is essential that the CNS has opportunity to acquire the information for more than a few seconds, and by repetition.

This then is the simple process of rote learning or mere memorisation of facts. Teachers of young children will recognise the similarity of this process with the 'Look and Say' method in reading. Children memorise certain shapes of words which from meaningful units, such as 'look Janet' and 'see the ships', by understanding the meaning, having them carefully spaced into groups which make sense, and then having them repeated over and over again. To assist in the memorisation, the words or phrases are accompanied by pictures which employ another important factor, namely, *association*, involving contiguity, similarity or contrast. Thus, rote memorisation has a part to play in education, however small it may be. In rote learning recall poses no problems since the child merely has to repeat the original words he learnt, or recognise them. In many areas of learning, however, mere repetition is not enough; we require more than this, namely, the application of our retained information to different learning situations.

We come now to the problem of *forgetting*. What causes us to forget? Is it the very nature of the CNS to monitor all incoming information so that we are not burdened with certain trivia? Is there some selective apparatus which controls our whole ability to remember? Old folk, for example, seem to remember vividly episodes which occurred in their childhood, which they may repeat perhaps three times in the space of two hours, having forgotten that they have previously told us. As P. Nathan (10; p. 342) writes:

> 'There is a great deal of evidence from psychology that older memories tend to be retained better than recent ones, and that the longer something has been remembered, the more likely it will be retained in the future. Fixation of what has been retained improves with time, and conversely, the more recent memories are more vulnerable.'

A teacher is often surprised and dismayed that children are unable to remember certain facts which she expected the class to remember. This forgetting may be due to a number of factors such as:

1. The time interval between acquisition or registration and recall.
2. Repetition, or lack of repetition.
3. Interference of other learning activities.

4. Individual differences of learners.
5. Presentation of material to be learnt.

Let us consider these in a learning situation. The teacher presents her class with a certain body of knowledge and requires the pupils to recall the information as soon as possible after obtaining it in order to reduce the time interval between acquisition and recall. If this time interval is extremely brief, and the material is repeated a number of times during the interval period, there is a strong likelihood that the child will remember. Usually, however, a child will participate in a large number of other activities during the school day; and the effort involved in learning this new material may sometimes interfere with the recollection of earlier material. Discovery methods in primary schools and topic approaches in secondary schools would appear partly to overcome this problem since, apart from any other considerations, they allow pupils to continue for longer periods on work of a similar nature. Thus, time-tabling is partially the solution to this problem.

The fourth point was the individual differences of the learners, and with the trend towards mixed-ability classes it becomes vitally important to adapt both the work load and the level of difficulty of the material to each individual pupil. Before the child can remember he must, as far as possible, be encouraged to understand the material to be learnt, and to make it his own. Finally, the recall of lessons learnt is greatly assisted by the method of their presentation; important facts to be remembered must be presented in a visually stimulating way, clear in their detail and relevant to the child's interest. This arousal of interest is the topic of the next chapter and really part of a larger concept in psychology known as motivation.

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Chapter 6

Motivation, Emotion and Learning

Motivation for learning is clearly a major problem for teachers. Why is it that children appear to learn and remember some things out of school more readily than other things in school? If you watch children playing some of their games, such as marbles or hopscotch, you will be amazed at the number and complication of the rules that exist, yet they are easily understood and applied by even very young children at the infant stage. It is also noticeable how some older children, who appear to drift through their secondary school life in the lower streams with little interest or little ability to read, are able to discuss the pop tunes of vocalists, the words of the songs, the different instrumentalists and often their past records and hits. Again, there are secondary schoolboys who speak with a great deal of expertise and almost professional knowledge about the workings of the motor cycle, or about the motor-car engine. Yet these are the same pupils whose record cards reveal them to have below-average attainment when they are required to learn far less complicated matters during school hours. One often notices the general air of enthusiasm among the first-year pupils of the infant school as compared with the look of boredom on the faces of many pupils in our secondary schools. What has happened to the eager 5-year-old who becomes the laggardly 15-year-old?

This gives rise to the problem of motivation. Obviously there has occurred, between the ages of 5 and 15, some change in attitude in these children. Are there, then, some physiological changes taking place when we are learning? In an earlier discussion it was stated that learning was the more or less permanent change in behaviour. This change or adaptation in behaviour appears to begin as soon as the child is born, and one of the major adaptations it makes is to breathe. The child appears to be 'motivated' to stay alive and consequently it exhibits a fairly wide variety of behavioural patterns such as breathing, movement, digestion and certain other responses to external stimulation, whether tactile, auditory or visual (1; p. 14).

The new-born baby does not remain passive and certain physiological needs have to be satisfied. These basic needs are primary and the execution or attempt to satisfy them is known as *primary* motivation. In a consideration of primary motivation we are involved in a discussion of the *autonomic nervous system* (ANS), which affect our emotions and, therefore, our individual behaviour in particular circumstances. Emotions are concerned with the way an individual reacts to his environment, and if those emotions are intense there is some disturbance of the intellectual functions, and inevitably there is some effect upon learning.

The ANS, as its name suggests, is largely self-regulating and independent of the brain and the CNS, although there is a direct link through the hypothalamus It is from here that the ANS could be said to originate, and from here its nerves and fibres lead to the different organs of the body such as the heart, lungs, stomach, intestines and other visceral organs, as well as to the sweat glands, muscles of the hair, and the iris of the eye. These nerves therefore go to the smooth muscles which are slower acting and more automatic; the skeletal or striped muscles connected to the limbs activate more on the principle of levers and are in most cases directly under the control of the CNS. The following diagram illustrates the basic structure of the ANS and also indicates the two divisions into which it is separated.

The two divisions of the ANS are the *sympathetic*, whose fibres come mainly from the middle section of the spinal cord, and the *parasympathetic*, whose fibres come largely from the two ends of the spinal cord (see Fig. 26). The majority of organs have fibres from both the sympathetic and parasympathetic divisions, for they are to all intents and purposes complementary and their functions are often in opposition. By this means the range of movement or action of these organs is kept well within reasonable limits, although at certain times of stress one division or the other has supremacy. Activation of the sympathetic system is sometimes known as *mobilisation* because in a sudden emergency the body resources are, as it were, mobilised for action, such as:

1. Contraction of the arteries.
2. Acceleration of the heart-beat.
3. Dilatation of the pupils of the eyes.
4. Inhibition of the contraction and secretion of the stomach.

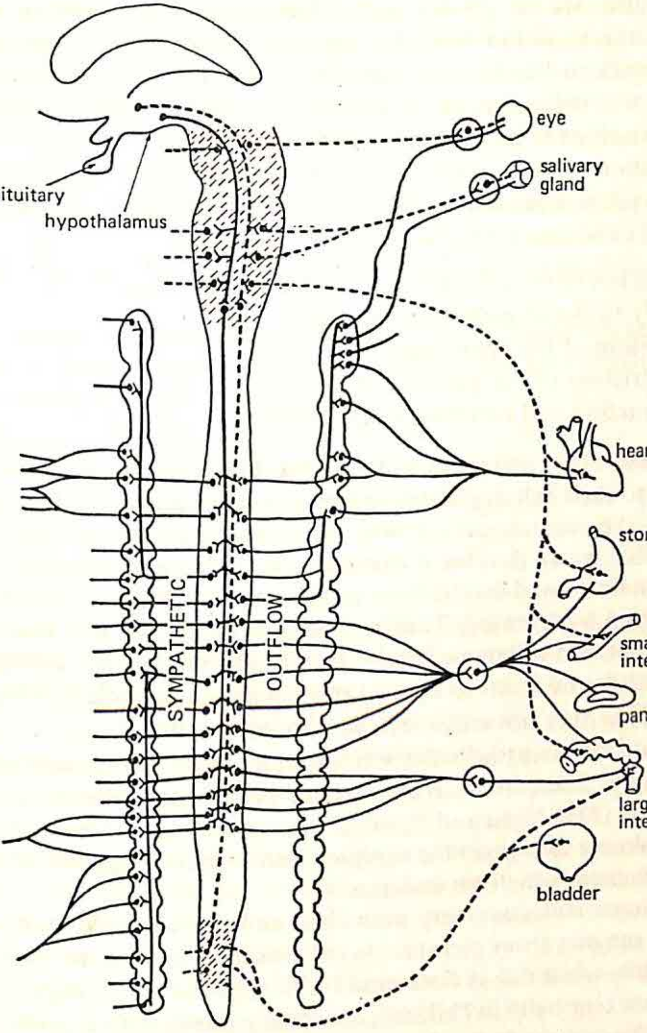

Figure 26

The sympathetic division diminishes the circulation of the blood by contracting the blood vessels which serve the intestines, stomach and other organs of the digestive system, while at the same time enlarging the blood vessels which control the flow of blood to the muscles which serve parts of the branch and the limbs. By causing the heart to beat faster it thereby forces the blood to flow to those organs of the body which are in greater need. The sympathetic division also controls the secretion from the salivary glands, hence a person's mouth tends to become dry when he or she is frightened. Extreme emotion will sometimes cause a child to urinate or defecate because the contractions of the bladder or bowel are affected.

Activation of the parasympathetic division tends to have the opposite effect, known as *conservation*, in which the above-mentioned four functions are reversed:

1. Dilatation of the arteries occurs to permit the blood to flow more readily to the intestines and stomach.
2. Inhibition of the heart-beat.
3. Constriction of the pupils of the eyes.
4. Contraction and secretion of the stomach.

We have all experienced some of the bodily changes listed, not perhaps to their full degree but sufficient to appreciate that they exist and that they are something over which we have little control. The control that we do develop is over the overt behaviour manifested by these emotions, and moderation in this overt expression appears to be acquired by learning. Thus, a young baby gurgles and chuckles with delight, but will immediately change to tears when it is unhappy; and as adults we learn to control our behaviour, especially when in public. This does not mean that we should be without emotion, but that we do not necessarily flee when frightened or become aggressive when angry. Today the two extremes of behaviour, described by W. B. Cannon (2) as 'fight and flight', are recognised as categories which are too simple to express the complex emotional feelings and physiological changes which we undergo.

Emotional states are very individual and cover a wide variety of feelings ranging from pleasurable enjoyment of a story to states of sheer panic when one is confronted with some terrifying experience. Emotions, especially in children, are closely linked with security and pupils often exhibit indications of their basic insecurity when dealing with subjects or topics which they fail to understand in school. We shall consider this aspect in more detail later, but at the moment it is necessary to mention another physiological aspect, that of the role of the *endocrine glands*. These glands are internal and they secrete substances called hormones directly into the blood stream. Such glands are known as ductless glands, and those which have some bearing on behaviour are:

1. *Pituitary gland:* sometimes known as the master gland, it is situated near the base of the brain and secretes hormones which activate or inhibit other glands. It is partially controlled by the CNS.
2. *Thyroid gland:* located in the neck, it produces a hormone known as thyroxin which controls the rate at which energy is produced in the body.
3. *Adrenal glands:* located just above the kidneys, they release two hormones, adrenalin, and noradrenalin, and although partially under the control of the CNS they are actively concerned with strong emotion.
4. *Gonads:* these are the sex glands of the male and female which are named the *testes* and the *ovaries* respectively, and which release sex hormones.

These physiological changes which take place need to be controlled so that the basic balance or metabolism of the internal environment is not disturbed beyond acceptable limits. We apparently have no external control and the whole system is self-regulating. This self-regulating mechanism is known as *homeostasis* and it keeps the state of the body within certain physiological limits. An analogy is the household central heating system in which a state of equilibrium is maintained through the regulating action of the thermostat. For human beings the process is illustrated by the secretion of insulin in the pancreas; when insulin is deficient the individual suffers from diabetes. Common examples are the fact that we perspire to lower our body temperature and shiver to raise it. Moreover, we are motivated to overt changes in behaviour because of our need for warmth, and we either put on more clothes, or close the window, or turn up the heating. There is, thus, an obvious link between physiological changes and behaviour.

It is a fact that we often feel anxious before sitting an important examination; what exactly happens? The body is prepared for action, and the sense organs are activated while we wait outside the examination hall. This information is transferred to the hypothalamus and the thalamus, and the sympathetic division of the ANS moves into action. The digestive process is slowed down and more blood is directed to the brain and muscles where it is needed. Correspondingly the heart beats more rapidly to supply the organs, and breathing quickens to supply more oxygen, whilst the liver releases a ready supply of sugar (glycogen). Through the pituitary gland, which is situated very close to the hypothalamus, the adrenal glands release adrenalin which is vital in the mobilisation of energy, by assisting in the quickening of the heart rate and the releasing of more sugar into the blood for energy. These two systems, the sympathetic and the endocrine (ductless gland), then combine to produce that sinking feeling in the pit of the stomach and the nervous excitement which we experience before we enter the examination room. It should be noted that if these emotions are not regulated by homeostasis then some disorganisation of behaviour will occur.

In primary motivation, then, such biological factors as hunger, thirst, sex and sleep arise because of internal physiological changes in the body often due to some external stimulus, such as a smell or a noise; to tissue needs, such as the metabolism of the various cells and organs which cause hunger and to the flow of various hormonal substances in the blood. The response to such changes, or homeostasis, was described by W. B. Cannon as 'the tendency of the body to maintain balance among internal physiological conditions' (2). For example, the need to drink arises because physiological requirements are such that the organism demands liquid to restore the balance. The drive arises because of this need, and the organism is motivated to obtain liquid; thus a wild animal will make its way to a drinking hole, a domesticated animal will make its way to its drinking bowl, and a human being will make his way to the cold water tap. The drive in these circumstances is the energising aspect of motivation. In our consideration of the work of Clark Hull in Chapter 2 we encountered drive theory and Hull stated that the reduction of the need was the motivating factor. This drive-reduction theory was supported by psychologists during the 1940s, but its weakness and circularity became increasingly obvious when it was applied to children rather than animals.

Another problem considered by proponents of the drive-reduction theory was the obvious motivating factor of money, which could in no way be called biological or primary. An early experiment by Wolfe (3) in 1936 showed how chimpanzees learnt to obtain reward or payment (grape or raisin) by putting poker chips into a vending machine called a chimpomat. In this experiment the chimpanzees could earn the chips in various ways. One way was to pull into the cage weighted boxes which had poker chips hidden inside them. The chimpanzees learnt to pull in the boxes to collect chips which they hoarded until the reward was required, and then they cashed the chips in. They learnt that different coloured chips gave different rewards, for example, a red chip for food, a blue chip for water, and a white chip for release from the cage or freedom. The chimpanzees were observed to work hardest for the particular coloured chip which satisfied their immediate need. The analogy to money is obvious, and the drive-reduction theorists postulated *secondary motivation* which assumed that through classical conditioning the basic biological need, say hunger, became associated with the poker chip. The latter then became the reinforcing agent or the reward through which the need-tension was reduced. And, of course, when one examines behaviour it becomes difficult to separate out the primary biological needs and their secondary motives. For example, a father with a family to support works, initially, to satisfy his own and his family's primary needs so that they are not deprived in any way. To do this he has to acquire money which he cashes in order to provide the goods to satisfy those needs. In time he may be very successful at this, and will become able not only to satisfy his family's needs but also to hoard, bank, or invest some of the money. He and his family may, indeed, have more than sufficient money to satisfy their wants for the rest of their lifetime; but the father does not necessarily stop working or acquiring more money. In fact, in most cases the acquisition of money now appears to be the primary motivating factor.

Thus, it becomes extremely difficult to separate the primary and the secondary motives; but it is now generally accepted that the study of motivation as a mere development of primary and secondary drives is inadequate not only for learning in school but for all learning. N. E. Miller (4), in an article entitled 'Analytical Studies of Drive and Reward', has presented a concise review of much of the research with animals and the primary motivating factors of hunger, thirst, sex and so on. The problem in the consideration of primary or physiological drives is the fact that some form of deprivation has to be established before motivation is evinced. For example, a partially starved rat will run a maze faster to reach the goal (food) than a satiated one; but Harlow (5) found that this was not so with monkeys involved in certain discriminative problems. In fact he suggests that 'tissue needs' are less motivating than curiosity or some manipulating drive. In more recent investigations D. E. Berlyne (6) has expressed current concern with motivation in his statement that:

'We find ourselves forced to recognise that the disturbances that

> motivate behaviour can come not only from external irritants, visceral upheavals and deprivation of vital substances but also from clashes between processes going on in the central nervous system. Related to these additional sources of motivating there must be a wide range of overlooked reinforcing conditions that can promote learning of new behaviour patterns. In opening up these new prospects the study of curiosity, exploration and epistemic behaviour merges with developments in several other areas of psychological research . . . including personality theory, ethology, child development, education, attitude change, social interaction, aesthetics and humour.'

In even more recent experiments, making use of an electroencephalograph (EEG) – an instrument employed for recording the rhythmical electric currents which pass through the brain – D. E. Berlyne and P. McDonnell (7) considered the EEG response of over a hundred male college students to different visual stimuli. They concluded that characteristics of the external environment such as surprisingness, novelty and complexity could induce heightened drive 'independently of visceral needs and receptive events'.

It is now suggested that a division of motivation into the two categories of physiological or primary, and of social or secondary, is too simple a position, and as more and more research investigates this area it appears that many of the 'drives' which were attributed to social learning might actually be primary. Harlow, for example, has shown that with young monkeys the need for affection was not associated with the alleviation of hunger or thirst. He examined the hypothesis of psychologists, sociologists and anthropologists who commonly held that the infant's love was learned 'through association of the mother's face, body and other characteristics with the alleviation of internal biological tensions, particularly hunger and thirst' (8).

Harlow reared eight monkeys with surrogate mothers which were of two types: one was a bare wire cylindrical form with a crude face, and the other was a wire frame sheathed and softened with terry cloth. Four of the monkeys received their nourishment from the first type of surrogate mother, whilst the other four received theirs from the more 'cuddly' mother. In both instances the food was accepted through a bottle with nipple attached to the 'mother'. Harlow found that the four monkeys who received their nourishment from the first type of mother spent only the time with her that was required for feeding and no more. This, he concluded, contradicted 'the idea that affection is a response that is learned or derived in association with the reduction of hunger or thirst'. Also interesting in this experiment was the contrast in the social behaviour of the two groups of monkeys, which highlights the importance of early upbringing.

It is clear that individuals are motivated by many factors other than hunger, thirst, affection and sleep, such as the need for status, social approval, security and achievement. But all such motives appear to serve, as Mouly (9; p. 63) indicates, three important functions:

'(*a*) They energise, i.e. activate and sensitise the organism towards certain stimuli.
(*b*) They direct behaviour towards certain goals.
(*c*) They reinforce behaviour that is effective in the attainment of desired goals.'

Let us accept these three functions whether applied to primary or secondary motives and see how the teacher can assist in their operation. Motivation may be considered as either intrinsic or extrinsic; intrinsic motives include those of exploration and curiosity, and extrinsic those of status and social approval. It will probably be agreed that one of the problems in the classroom is to guide intrinsic motivating drives towards goals which meet with social approval.

Young children entering school for the first time are not only highly curious and inquisitive but also more than willing to explore and manipulate new materials. Unfortunately few teachers of children in our non-selective secondary schools find that the same children are highly motivated towards status in society or social approval. In fact the position is often reversed since some secondary school children appear to be motivated almost towards social disapproval. This is a very serious matter and it is difficult to contemplate the concept of motivation apart from social considerations. In this respect we are very much involved with *parental attitudes and aspirations*; and if we consider three pupils Susan Kenny, Michael Brown and Malcolm Weir, we may well find that Susan's success and satisfaction are bound up with both teacher's and parental approval whilst the failure of both Michael and Malcolm – although from very different backgrounds – relates very closely to the vacillating or non-existent interest of their parents. If Michael's father is interested only in his son's sporting or athletic prowess Michael may seek approval solely in this area and to the detriment of his academic work. And if Malcolm is one of six children born to poor and ignorant parents, he may find that they are far too concerned with the problems of survival to be in any way involved in his scholastic career.

Children like Malcolm gradually develop an attitude to school in which, from being positively motivated at 5 years they become, by the time they are 15, thoroughly negative in their motivation. This means not merely that they are negative in their attitudes to learning and just while away the school hours, but also that some develop an obstructive attitude and prevent themselves and others in the class from learning. They represent the disruptive element in the secondary schools whose motivation has gradually changed from positive to negative. J. W. B. Douglas (10), who directed a team investigating the selection of children for secondary schools, has this to say about parental aspiration, that 'it seems that children who are encouraged by their parents do better in selection examinations than their measured ability would predict and those who are not encouraged do worse'.

Closely linked to this area of parental aspiration is *teacher aspiration*. Sociologists frequently tell us that children from working-class homes are at a disadvantage at school because the school is an example of middle-class culture and is therefore alien to the child from the poorer home. The teacher himself is also more likely to be middle-class and to understand and appreciate the aspirations of Susan's parents for Susan, and he will expect more from Susan than (say) from Malcolm. By expecting more from Susan he will probably unconsciously encourage her, spend that little extra time over her work, hear her reading more frequently, see that she has a suitable reading book, and express concern and surprise when she does not reach the required standard. Remarks such as, 'I expected better work from you Susan', and 'This is just what I would expect from you Malcolm', reflect the different levels of aspiration which the teacher has for the two children. Naturally we find that the one tries that little bit harder while the other makes less effort, and in fact both are living up to their teacher's aspirations for them. This tends to be extended throughout their school career and indicates that Douglas's investigation is substantiated.

The motivating factor of teacher and parental aspiration is also reflected in the organisation of the school. Without entering into the controversy of streaming versus non-streaming, we must consider streaming in relation to the problem of motivation and aspiration. If a child is placed in the 'A' stream or top group then the teacher and parent expect a high standard of work, and usually obtain it. If a child is placed in the 'C' stream or slow-learning group then his standard of work is expected to be lower, and it invariably is. This is merely an administrative extension of the psychological phenomenon of aspiration, and we must expect (or at least not be surprised) that 'A'-stream children will develop 'A'-stream ability, interests, characteristics and ambitions, and 'C'-stream children will develop 'C'-stream ability, interests, characteristics and ambitions. All teachers must therefore be aware of their importance in the motivation of the children they teach.

If we accept that children are intrinsically motivated to explore, to manipulate, and to satisfy their curiosity, then the variation of these drives with the individual is partially dependent upon motivation, physical opportunity and social environment. These last two factors are so dependent upon child-rearing practices prior to entry to school that the teacher has either to build upon the foundations already established, or if possible attempt to establish them. This can be done in various ways dependent to some extent upon the age of the children. Most children, however, have a need to achieve success, but for slow children this need is rarely, if ever, satisfied. They are constantly set tasks in which they are unlikely to succeed compared with their more intelligent peers, and probably they find this sense of failure reinforced at home when they are judged against their brothers and sisters.

D. W. White (11), who considers the ability to carry out a successful interaction with the environment as part of the stimulation theory of motivation which he labels *competence*, incorporates activity, exploratory curiosity and manipulative drives in this concept of competence. Successful interaction or activity is therefore essential in any of these areas. This competence and success is closely linked to the achievement motive, as described by J. W. Atkinson (12), with its social implications. Achievement is important for self-respect and it has been found that in middle-class homes this is promoted especially by mothers who encourage their children, particularly boys, to be independent and to attempt new things. Children in less fortunate homes are less likely to be encouraged to experiment in different activities, and so will find the adjustment to school somewhat more difficult. They are also less ready to accept failure and therefore do not flourish or expand in their interests but tend to become more restrictive in their outlook.

The teacher has a great responsibility to establish the standard of work which the individual child can master to ensure success, and at the same time to provide material which will stretch the pupil and develop his potential. This is no easy task and requires a deep understanding of individual interests and aptitudes as well as systematic planning and preparation. Children need to think well of themselves and to have some attention paid towards them. This is really the development of a self-concept which is the way the person sees himself in relation to the environment, and which to a large extent governs the way he interacts with that environment. A child who constantly fails to achieve success, especially with reading in his first year at school, may well begin to regard himself as stupid and expect to fail at work connected with school. This attitude will colour the way he interacts with the school environment and also the amount of success or failure expected or experienced. There is a strong element of the self-fulfilling prophecy in this and the child gradually builds up a self-concept closely linked with either success or failure in the classroom and in many school activities.

The aspects of motivation so far dealt with have been mainly intrinsic, but very few children will learn merely because they have an innate desire to remember (say) the causes of the Civil War, and it is the teacher who has to provide the extrinsic motivation. The teacher has a variety of methods at his disposal, some of which are largely predetermined by the organisation of the school, but within the different organisations he has the opportunity of achieving considerable success. To be successful, however, children need to pay attention and they will do this when the work matters to them, and when they are involved as persons and their self-concept is fulfilled. The attempt to involve children merely by saying, 'Pay attention to me!' is often unsuccessful; most children require some positive goal to work for. Now this might be merely the teacher's approval, for young children are *anxious* to please their teacher; but as they progress through their school life this particular desire for approval becomes less motivating.

Anxiety has become an important concept in motivation. In child-rearing practices and in the psychology of child development it is suggested by many that anxiety appears in relation to the mother's love, or that it is perhaps a development from maternal love. The child, having a need to be wanted or cared for, becomes anxious when this love from the mother is withheld or withdrawn. Maternal disapproval evokes a feeling or emotion which we call anxiety, and which is an unpleasant state that the child seeks to relieve. When the child enters school he may well transfer the role of the mother to the teacher, and in order to avoid the painful experience of anxiety he is motivated to please the teacher and gain her approval. Much of our social learning in the home is achieved in a similar way. We begin to know what displeases our parents, and in order to avoid incurring their displeasure, with the accompanying discomfort of not having their affection and approval, we conform to social obligations.

The role which anxiety plays in learning has been closely linked with the fear of failure, and it is a state of unease which we all attempt somehow to relieve. According to J. W. Atkinson and G. H. Litwin (13), people with high achievement levels will take moderate risks, whereas people with high anxiety ratings prefer either high or low risks. Children as well as adults have different levels of anxiety and, although some tension appears necessary for learning, too much causes disorganised behaviour and sometimes complete failure. The teacher has to try and estimate how much anxiety the individual pupil can accommodate, and so adjust his own level of aspiration for the child accordingly, in order that effective learning might ensue.

In a consideration of the problem of anxiety one must refer to the role of competition in school. Competition can clearly increase anxiety; but some would argue that this is a highly competitive world and school should reflect society. Moreover, it is in this way that children learn to adjust to life and adapt to the circumstances they will find when they leave school. No one will deny that competition is highly motivating for those who are likely to achieve success, but it can have the opposite effect upon children who are unlikely to excel in any work. There are other issues to be considered as well. In progressive education a great deal of stress is placed upon group work, and competition here can be of great value to all ranges of ability if within the groups the best are encouraged to help the weaker, while the groups tend to compete with other groups. Children enjoy some form of competition – if only by striving to improve upon their own previously best assessment. In this way the teacher will motivate the child to raise his personal standard as well as to fulfil his need for attention, affection and recognition.

Later on in school life, perhaps at the secondary school stage, the need for competition may be lessened since pupils of this age tend to develop their own goals which they wish to attain. Often they are motivated by the imminence of external examinations, where in a sense they are competing not against one another but against the examiner. At this stage the problem of competition and co-operation does not necessarily arise. Of course there will be a number of children to whom the incentive of success in an external examination does not apply. Here the school and the teacher have to ensure that the work they are following in the classroom is significant in terms of the occupations and opportunities that the pupils will encounter when they leave school. Too many of our secondary boys and girls drift through their last year at school poorly motivated and uninterested in their school activities, partly because they consider that much of the subject-matter is utterly irrelevant. The teacher must attempt to relate school work to real life and to motivate these children by awakening their interest, developing their individual skills and showing them that their personal development is important not only for the occupation they will take up, but also for the contribution they will make to society. In this respect individual skills and hobbies are of great importance and can become a starting point for school work as well as for leisure-time activities. According to J. W. Atkinson *et al.* (1953) (14), high achievers or those with high-achievement motivation are involved in community activities, work harder at tasks where completion can be effected by one's own skill, prefer to work with experts rather than friends, worry about uncompleted tasks, lose interest where the result is by chance or merely routine, and are usually competitive, confident and competent. From this it appears that if teachers, by their own high level of aspiration for all children, raise the latter's achievement level then the characteristics developed would solve many of the problems of motivation, particularly during the period of adolescence.

As children complete the secondary stage of schooling the more complex social motives tend to develop, such as the wish to be affiliated to clubs and societies. Thus we have in our secondary schools geographical societies, history societies, chess clubs and cycling clubs which are important for the adolescent. The latter is also developing a need to achieve some status, which he can do through these clubs by being consulted about the courses he is to follow at school, to be given the opportunity to offer suggestions about the syllabus to be followed and to be permitted to express opinions about the organisation of the school. In this way he will be motivated to take a more active part in the school community and come to realise that any society is dependent upon the activity and interest of the individual. Children respond to this feeling of involvement and need to have some attention paid to them; indeed, where research has investigated the effect of praise and blame on children in school it has been found that groups of children who are ignored completely make less progress than those who are constantly reproved. Praise and blame appear to be equally motivating at first, but constant blame soon leads to poorer work than that elicited by praise.

This chapter began by saying that motivation was a major problem for teachers. It is, in fact, the key to successful learning and teaching, and without motivation – whether primary or secondary – learning does not take place. Although simple learning is dependent upon psychological changes such as drinking to quench thirst and eating to satisfy hunger, much of our learning in school is dependent upon social or secondary goals. The primary drives of exploration, curiosity and manipulation must be guided along socially approved channels in order to reach a desired goal which is satisfying to the child. It would seem that the subject-matter taught must have significance for the individual, that work must be systematic and sequential, and that the learner must be able to understand the stages involved. The level of attainment required must be adjusted to the individual's ability and level of aspiration which are often related to the child's past experience of success or failure in school. Knowledge of results is important and should be given to the class as soon as possible; and in general rewards are more effective than punishments and help to establish a more stable emotional climate in the classroom. Success is essential and needs to be emphasised – not failure – and this must be closely related to a realistic level of aspiration for the individual pupil.

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Chapter 7

Development and Learning

Up to the present we have discussed some of the different ways in which a person learns, and we have also considered the physiological changes which take place during the learning process. It has been noted that it is not easy to distinguish between the physical changes and the so-called mental changes; in fact, each process affects the operation of the other. Further, we have noted how our emotions play an important part in directing our attention to what we are learning. Our attitudes affect how we comprehend or interpret the ever-present stimuli in the environment. Other factors which also affect our learning are the changes which occur with the passage of time. These are often physical changes because the kind of response or learning of which we are capable is often limited by our biological equipment and our stage of development. An obvious example is that at no stage of human development would we be capable of flying, or of living under water, without either some drastic change in our biological equipment or at least an artificial aid. The development of our physical attribute also is essential, since physical maturity largely decides when a young child learns to walk or accomplishes some other physical skill. As there is a progress through stages of physical development, for example, sitting, crawling, standing, walking and so on, there is also a developmental process in learning capacity. Cognitive theorists, especially Jean Piaget whose work we shall consider in more detail later in this chapter, suggests that there are also stages in mental or intellectual development.

What is this concept of development? Development in itself is basically biological – that is, it is concerned with the changes in the human organism which occur over a period of time. Development is also determined by heredity and the environment, and the underlying problem is that of the relationship between these two factors. Man is basically biological, and it is this biological structure which has influenced the environment in which he lives, so that the underlying problem is that of the interaction between nature and nurture.

Let us first consider, however, the basic mechanics involved in human genetics, that is, the mechanics of heredity. The *sperm* of the father unites with the egg or *ovum* of the mother to form an entirely new cell, known as a zygote. This fertilised egg is not really a new organism in a biological sense for it has already existed in the parents. Both the sperm and the egg, however, contain tiny structures known as *chromosomes*, which in turn have on them *genes* essential for the development of some bodily growth or human characteristics of behaviour. Each human zygote contains forty-six chromosomes, twenty-three inherited from each parent, and it has been discovered that an abnormal number of chromosomes tends to be related to abnormal development, as in the case of mongolism. The genes, which are now accepted as the units of heredity, act as enzymes; that is, they stimulate the chemical processes inside and outside the cells without undergoing any change themselves.

Three distinct cell structures appear to form the *egg stage* – the *ectoderm* or outer layer which develops into the sense organs and nervous system; the *mesoderm* or central layer which develops into the skeleton, muscles and circulatory system; and finally the *endoderm* or inner layer which produces the digestive system and internal glands. This stage lasts for two weeks and when the *amnion*, or water sac which contains the embryo, and the *placenta* which connects the embryo to the mother, are formed after the first two weeks this next stage is known as the *embryo stage*, lasting until the seventh or eighth week. The *foetal stage* sees the development of the limbs and of the reaction to stimulation, which indicates the establishment of a nervous system with both input and output pathways; this process occurs through the spinal cord, not the cortex. Towards the end of this period the eyes open, and by about the thirtieth week the foetus is capable of independent life outside the uterus. In other words, if born prematurely the organism would probably survive. For the next ten weeks the foetus acquires the refinements of the human organism and after approximately 280 days the child, about 20 inches long and around 7½ pounds in weight, is born. Its cell structure is complete in number although not in size and the *neonate* (as it is called for the first few weeks of life) spends most of its time either sleeping or in a semi-comatose state, curled up in the foetal position. During this period the neonate has to adapt to the strange and rude environment, to learn to breathe, to make temperature adjustments, to digest nourishment and to eliminate waste products – all of which were unnecessary before birth. These are physiological changes, but there are other adaptations which could be termed psychological and which develop later, being often dependent upon maturation and learning.

Maturation is an important concept in development, and it requires some explanation. Learning is, we understand, a more or less permanent change in behaviour arrived at as a result of experience, it may be intellectual and motor as well as the acquisition of attitudes and fears. Maturation is the process of the gradual unfolding of the inborn capacities which must be coupled with physical growth and the development of the CNS. Teachers speak, for example, of reading readiness and this is one aspect of maturation. By this it is meant that at some particular stage of development an individual has reached a certain physical and intellectual standard when the presentation of written symbols can be meaningfully transferred into words. Certainly there are approximate ages at which a child will profit from specified educational experiences, but these must not be too closely related to chronological age, as often happens in our educational system. We move our children from different schools at strict chronological ages regardless of their level of maturation. We even move them up through the school, year by year, in the same manner. This is, of course, largely the result of administrative needs and on the assumption that there is an average child with an average rate of development. Unfortunately development in all aspects appears to proceed in fits and starts – whether it be physical, intellectual or temperamental – and this makes the organisation of education by the criterion of chronological age rather crude.

As it has been said earlier, development certainly proceeds in general stages, as evidenced by such physical abilities as sitting, crawling, standing and walking, and there is strong evidence to show that these and other human attributes are the result of some inborn time mechanism, and are largely unaffected by the environment. For example, Dennis and Dennis (1940) (1) noted that, although the Hopi infants are strapped to a board during infancy, this restrictive environment does not greatly affect the ability of these children to walk or run at a later stage in comparison with other children. This does not mean that the environment is not important but rather that maturation itself puts a limit on the influence of the environment. The environment, in fact, has a very vital part to play in learning itself, but to take a very obvious example it is no use teaching a child to skip when its physical development has not yet reached the stage of standing. Maturation in conjunction with teaching is the key to learning, but the problem for teachers is to know when there is sufficient maturation for the teaching of certain concepts. Intellectual maturation is very difficult to observe, and as the capacity of the child to learn is closely linked with the process of maturation it is essential that we are aware of the problems and the variations between individuals.

Not only do the rates of development vary from individual to individual but there is an interrelationship between the different aspects of development. Intellectual development is affected by physical development; for example, a child cannot learn to write until he has acquired the motor skill to hold and manipulate a pen or pencil. Social development is also affected by mental development; thus a child establishes social relationships with others more effectively when he can understand their needs and requirements or their position in society. Physical development also largely determines the child's social life; for example, a 3-year-old child is unlikely to be included in a group of children who are sufficiently developed physically to play rugby or to travel to the cinema.

We shall now consider generally the different characteristics of children at different stages, remembering that, although three stages are here delineated, development is a continuous process.

INFANCY AND EARLY CHILDHOOD: BIRTH TO SIX YEARS

This period is one of rapid development, during which the baby changes from a creature of unco-ordinated movements to a well-organised being capable of many complicated motor skills, independent and self-willed. He has a command of language which permits him to express his likes and dislikes and to communicate socially with those around him. Towards the end of this period a child often becomes boastful and aggressive; socially he wishes to be the most important person around and often appears extremely selfish and apparently insensitive to the feelings of others. Nevertheless he is probably experiencing strong emotions of fear and still requires the feeling of security and freedom from anxiety, and loneliness. In many ways the end of the period is not unlike the unsettled stage of adolescence, although the intellectual development which we shall study separately is very different.

MIDDLE CHILDHOOD: SIX YEARS TO THIRTEEN YEARS

The 7-year-old is often lively and active but rather more tranquil, and the whole period is marked by less reliance upon those in authority as represented by parents and teachers. Their emotions are kept remarkably well under control and consequently they find it easier to play in groups, to work with others in school and classroom activities, as well as to exhibit prowess in motor development. Because of these new physical skills they participate enthusiastically in all practical activities and respond wholeheartedly to any learning experience which involves some form of activity. It is upon this practical activity that their mental development is founded as we shall see later. Many teachers find this the most rewarding age group to teach as their pupils' interests and capabilities for all new learning reach a high level.

ADOLESCENCE: THIRTEEN YEARS TO EIGHTEEN YEARS

This much publicised period of adolescence has become almost a cult in Western society, and while one must be conscious of its stresses and strains it must also be noticed that it is only one stage in a developmental process. The development of the sexual characteristics themselves creates problems, such as menstruation for girls and ejaculation for boys. The growth of facial and body hair, and the development of the breasts, which reflect internal bodily changes, often lead to acute embarrassment. This period of self-fulfilment is one in which the adolescent has to learn to control intense emotions and changes in mood, and must attempt to achieve personal independence while at the same time maintaining and establishing good relations with other adolescents. New thinking skills appear at this time and the teenager becomes aware that the world is not divided simply into the good and the bad, but that personal value-judgements need to be made. He has to acquire his own values and can no longer rely upon those imposed by authority. This period of struggle and rebelliousness is often prolonged by the very structure of our society which encourages young people to avoid the full responsibilities of adulthood until many are in their early twenties. One of the most difficult problems of our time is to increase the real responsibility available for the older adolescent; but one fact does emerge clearly.

namely, that above all there is a great need for a sense of security which can really be found only in a stable home background.

This, then, is a very brief outline of the development process and the reader is referred to the writings of A. Gesell (2) and J. Hadfield (3) for informative and detailed surveys. It should be pointed out here that our primary concern in this book is with mental or intellectual development in relation to learning; but one cannot ignore social and emotional development, since all forms of human development are closely interrelated.

Jean Piaget was born in Neuchâtel, Switzerland, in 1896, and at the age of 10 he had published his first 'scientific paper' on his observations of a part-albino sparrow which he had observed. This was not only indicative of his precocious intellectual ability, but it was also the first indication of the method of his future work – that of observation. He proceeded to the University of Neuchâtel and was awarded his first degree in 1915, and his doctorate in 1918, after which he left the university to broaden his experience in psychology. In 1931 he became Director of Studies at the Institut Jean-Jacques Rousseau in Geneva, and it was from here that he initiated his now famous research and writing. It is impossible in a short space to evaluate his contribution to the study of child development. He has written more than 25 books and 150 articles (4).

We are, however, primarily concerned here with cognitive development, and Piaget describes this in terms of stages as thinking proceeds from the reflexive to the reflective. There are four important points to be made about these stages in order to avoid misunderstanding about his work, and Barbel Inhelder (5; p. 23) lists them as follows:

1. Each stage involves a period of formation (genesis) and a period of attainment. Attainment is characterised by the progressive organisation of a composite structure of mental operations.
2. Each structure constitutes at the same time the attainment of one stage and the starting point of a new evolutionary process.
3. The order of succession of the stages is constant. Ages of attainment can vary within certain limits as a function of factors of motivation, exercise, cultural milieu and so forth.
4. The transition from an earlier to a later stage follows a law of implication analogous to the process of integration, preceding structures becoming a part of later structures.

Let us consider these in slightly more detail, remembering that Piaget is referring to cognitive development, and that this is just one part of human growth. Piaget's theory, as might be expected because of his early training, is basically biological; he seeks to explain development as a process of adaptation to environment. Only quite recently has a more sophisticated approach been made to the interaction between heredity and environmental factors involved in the development of intelligence. With a greater undertanding of the part played by the chromosomes and genes in carrying information from one generation to another, there has been a relaxing of the rather restricting theories of the extreme environmentalists and behaviourists. Development is recognised as a continuous process of interaction between the organism and environment with neither absolute genetic control nor absolute environmental control, but with each element modifying the other. Piaget has shown that intellectual growth is not dependent merely upon maturation or the unfolding of innate structures and potentialities, nor is it dependent entirely upon environmental structures, but upon the constant interaction of these two. Another point to be made is that Piaget is not an educational psychologist; he has never set out to tell us what to teach and when, but his work has been applied by educationalists along these lines. What Piaget has done is to reveal that the child's understanding of the world is very different from that of his parents and teachers, and furthermore the child's construct of reality changes as he grows older.

It was said earlier that Piaget's approach to development in intelligence was basically biological and was a process of adaptation. Development to him is rooted in what is past, but with these structures constantly changing to meet new demands. These changes in structure brought about by the effect of the environment are called *accommodation* by Piaget; and the ensuing changes in the environment to accommodate it into the existing structures he termed *assimilation*. In other words, a new structure is constantly being evolved to maintain a balance between these factors of accommodation and assimilation, and the maintenance of this balance is what Piaget calls *equilibrium*. Equilibrium must not be thought of merely as a state of balance, but also as the preparation for another state of disequilibrium. The organism has to be constantly active and equilibrium is perhaps better understood as the relationship between the actions of the organism and the environment. As Piaget says:

> 'Equilibrium is synonymous with activity. In the field of intelligence the same holds true. A structure is in equilibrium to the extent that an individual is sufficiently active to be able to encounter all intrusion with external compensations. Moreover the intrusion will ultimately be anticipated by thought' (6; p. 151).

It is the very structure of these actions with which Piaget is concerned and he describes the totality of a behavioural sequence, such as grasping a bottle, as a *schema*. A schema is in some ways a concept or strategy, which implies that each action, for example, that of grasping is never exactly the same. The way one grasps a bottle is different from the way in which one grasps an egg. A schema is then an extremely flexible structure which is capable of adapting the actions of the organism to assimilate the changing environment. Because of this, schemas (or schemata) must be cognitive structures capable of repeating a strategy with similar objects in the environment as well as being able to extend their strategies to assimilate new objects. Cognitive development can then advance through these schemas as they increase their ability to discriminate and generalise. As D. S. Wright *et al.* (7; p. 500) state:

> 'Thus, the development of intelligence in terms of the progressive modification, co-ordination and differentiation of schemata can be described as follows. The biological drive to adapt the environment leads the child to assimilate the objects in that environment to his existing schemata. At the same time the nature of the environmental object forces upon the child an accommodatory adjustment of these schemata. It is thus that schemata develop. It follows that the complexity of schematic structure depends upon the variety of the environment.'

Piaget sees the development of intelligence as an erection of a vast building with each stage adding not only to the size but also, more importantly, to the stability of the structure. Another feature is that each stage of the structure is not only essential for its own functioning, but is also the starting point for the next stage.

We shall now consider the six stages of this structure as a child moves from reflexive to reflective thinking; these are as follows:

1. The reflex or hereditary stage.
2. The stage of motor habits.

3, The stage of practical intelligence.
4. The stage of intuitive intelligence.
5. The stage of concrete intellectual operations.
6. The stage of abstract intellectual operations.

For our own purpose the starting point of the child's intellectual development is his own action in the literal physical sense. The infant himself takes a controlling hand in his own development by organising his own experience of the environment, by following things with his eyes, exploring with his hands, mouth, feet and so forth. This process of absorbing experiences and organising them round the activities that produce them is what we have described as assimilation, and the enlarging or altering of the schemata to incorporate these new experiences of learning is what we have described as accommodation.

These six stages mentioned above are included in four major periods, each of which we shall consider in some detail. The four periods are:

1. The Sensori-Motor period (Birth to 2 years).
2. The Pre-Operational period (2 to 7 years).
3. The Concrete Operational period (7 to 11 years).
4. The Formal Operational period (11 to 16 years).

It should be noted, however, that these chronological ages are approximate only, and that the important thing is not the ages but the sequence of stages through which the child passes. Also it should be remarked that these periods merely pinpoint successive gains in the continuous process of adaptation; no break is involved in the evolution of behaviour.

THE SENSORI-MOTOR PERIOD (Birth to Two Years)

This period extends from birth to the acquisition of language and it is a time of rapid development. The neonate and infant, without the use of any language or symbolic representation, gradually constructs or organises the environment into a meaningful reality in which he places himself as a separate entity. This he does by perception and movement only. There are six sub-stages within this period during which the child progresses towards the formation of a permanent object, the level of intelligence without language (see Chapter 3 and Köhler's chimpanzees, p. 53), and the beginnings of representation.

Stage 1: Birth to One Month

The neonate is completely egocentric and its mental life is confined to the exercise of the sucking, crying, swallowing and grasping reflexes. But these become refined within the first two weeks and show signs of adaptation to the environment through experience. Nipples and bottles are sucked, whereas fingers and other objects are more quickly rejected. There is no differentiation between assimilation and accommodation.

Stage 2: One to Four Months

This stage represents the beginnings of the movement towards differentiation between assimilation and accommodation, although the infant is still really completely egocentric. Piaget now introduces the concept of *circular reaction*. Up to this point, the neonate has only a sensori-motor schema, that is, sucking, grasping, etc., at its command but this now undergoes a slight change. The infant applies the sensori-motor schema but the response obtained is different from what is anticipated or intended. The infant then repeats these new movements immediately and establishes a new schema, which is repeated again and again. This process of adaptation and repetition is the circular reaction, the forerunner of intellectual development.

Stage 3: Four to Seven Months

Whereas Stage 2 saw the introduction of the *primary circular reaction*, in Stage 3 Piaget introduces the *secondary circular reaction*. The main difference is that during Stage 2 the infant was concerned merely with its own activities of sucking and grasping, but in Stage 3 he becomes interested in the results of his actions. In other words, he will grasp and scratch objects in order to see or hear the effect of these actions. These are the beginnings of a means/end differentiation, and by the end of this period there is an adaptive recognition of objects to be banged, rattled and sucked, as well as the beginnings of the concept of the permanence of an object when it is out of sight. This is evidenced by the anticipation of the complete object when part of it only is seen.

Stage 4: Seven to Twelve Months

This stage is important because by the end of this period the child exhibits genuine means/end differentiation. He shows intention by removing obstacles which hinder his reaching a goal; for example, a cushion will be removed to obtain a toy. This also indicates the development of a time sequence whereby the goal (the toy) is in the future, and the obstacle (the cushion) represents the present which has to be removed. The child also tries out all his schemata on new objects and does not regard them merely as objects of novelty. It is almost as though there were an attempt to place them in the reality which the child is gradually forming concerning this environment.

Stage 5: Twelve to Eighteen Months

By the end of Stage 5 the child has possibly reached the highest form of intellectual development conceivable without language. In order to reach objects out of range a stick will be used as a rake; this is comparable to the adaptive behaviour of Köhler's chimpanzees referred to in Chapter 3. Piaget includes in this period the *tertiary circular reaction* as the child actively experiments with a variety of objects by banging, dropping, and throwing, as well as merely grasping and sucking, in order to study the effect of his own actions. There is thus the integration of one schema with another, which is analogous to the 'learning set' referred to in Chapter 4.

Stage 6: Eighteen to Twenty-Four Months

During the previous five stages the child has gradually developed the ability to separate out objects from his environment, and to conceive of their permanence when not visible. Now he becomes able to represent to himself internally a similar schema of behaviour which is independent of the clues of the environment. This beginning of *representation* is a form of mental anticipation which is essential for problem-solving behaviour and the invention of new means. This internalisation of the schema and the beginnings of representation are indicated by the development of imitative *play*, *imagery* and *expressive movement*, and more especially by the first indications of the use of language. All these four elements are symbolic, particularly language when it is used to stand for the environment, and so greatly advances the ability to anticipate. In fact, the child is beginning to think in a constructive way.

These are the six stages through which the child passes up to the age of 2 years, and they are of vital importance for his future mental development. From simple reflexes he reaches the stage where he is able to invent new means, foresee acts which may either fail or succeed (anticipation), and is able to represent to himself various combinations of a number of possible actions. From being entirely dependent upon sensory stimuli and *motor* activity (sensori-motor period) he becomes independent of sensory clues and is able to represent to himself internally the motor activity. This is a truly herculean achievement and these stages have considerable importance since early learning appears to affect all other stages and areas of development in later life. One must remember, however, that at the end of the sensori-motor period this 'thinking' is very slow and is in a fixed sequence or chain, and is also of a very practical nature directed towards the solution of practical problems.

THE PRE-OPERATIONAL PERIOD (Two to Seven Years)

This period is divided into two stages. The first is the period from 2 to 4 years which Piaget has termed the stage of *transductive thinking* (or pre-conceptional intelligence). The transition from sensori-motor intelligence to pre-operational thought is the change from the overt acts of the former to the inner, symbolic manipulations of reality. Sensori-motor intelligence is of the present, whereas representational intelligence can recall the past, represent the present and anticipate the future. In other words, sensori-motor intelligence is linked with direct action, and representational thought can be said to contemplate action. Although the child is no longer dependent upon immediate perception there are a number of limitations in his thinking. These are as follows:

1. The child sees all happenings from his own viewpoint only.
2. His thinking is irreversible; he cannot return to the starting point or operate upon his thoughts.
3. He will centre upon one feature only and is unable to establish any relationship between different features.
4. Inanimate objects such as the sun and the clouds he endows with human attributes. For example, children of this age will speak of the sun going to bed, or of the moon following people.
5. Although he has acquired some use of adult language he has not yet acquired adult thinking.

6. He has not achieved the ability to use language in conceptional thinking and cannot distinguish between the general and the particular. For example a 3-year-old does not know whether he eats the same orange each day or a different one, because he lacks the general concept of a class of object, to which a single fruit belongs. Similarly he is likely to call all men 'daddy' because of this lack of a concept of a class of things. This is known as a pre-concept.

At about the age of 4 to 5 years a change begins to appear and the child's thinking becomes a little more systematised. This second stage, which lasts until the child is about 7, is known as the period of *intuitive thinking*, and it is still governed by perceptions or stimuli from the environment. To explain what is meant by this it is easier to refer to a typical Piagetian experiment. Some liquid is poured into two identical glasses, (*a*) and (*b*), so that the level of the liquid in the two glasses is the same. The child observes this and is quite certain that there is the same amount of liquid in each glass. The liquid from one glass is then poured into a long thin glass, and once again the child is asked which glass contains more. He asserts that the tall thin glass (*c*) golds more liquid (see Fig. 27). Why does the child assert this? He does so because he is able to 'centre' on one aspect at a time only. He is said to centre on the height and to ignore the width. Even though he knows there was originally the same quantity in each glass, his inability to de-centre or handle two relationships at one time does not permit him to take into account features which could compensate for the distorting effects. It *looks* more, therefore it *is* more.

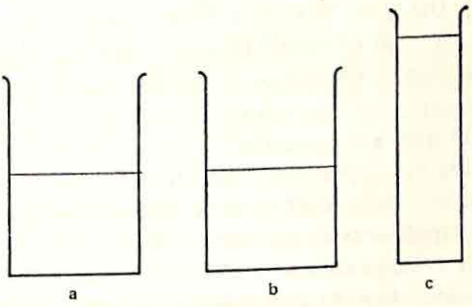

Figure 27

Another weakness in the child's thinking is also revealed. He is unable to see the possibility of returning the liquid to its original state; he is unable to grasp the problem as a whole or to range his thoughts backwards to the original starting point. His thinking is *irreversible*, and this lack of reversibility is closely linked to another important aspect, that of *conservation*. By conservation Piaget means the invariance of quantities, that is, no matter what transformations take place in shape it is always possible to return to the original. In the example above the liquid could be poured back into the original container.

This idea of conservation is also illustrated by taking a ball of plasticine. It is shown to a child of about 5 or 6 years, and then it is rolled out into a long, thin, worm-like shape and the child asked if there is more or less plasticine than before. Until he conserves in his mind the original quantity of plasticine the child will still be governed by his perceptions. It is not until conservation is acquired at approximately the age of 7 years that the child moves into the first period of logical thought – the *concrete operational period*.

THE CONCRETE OPERATIONAL PERIOD (Seven to Eleven Years)

This is really the first reasoning stage. The word *operational* is Piaget's term for what we would probably call logical; he means that the child is capable of thinking over actions which previously he had carried out overtly, and operations are actions which can be carried out in thought and are reversible. One of the most important acquisitions in the development of operational thinking is that of conservation, but it is important to note that although conservation is achieved it is applicable to concrete objects only; nevertheless the child's thought is beginning to conform to a system.

Let us consider again the experience with the liquid and containers. The child's very lack of conservation permits him to state categorically that the tall, thin glass contains more liquid. He is influenced not only by the perceptual information but also by his inability to conserve in his thinking the quantity of the liquid. It is only when he develops the concept or understanding of *permanence* that his thinking moves forward into this state. As another example let us refer to the experiment with the plasticine, in which the child is given two balls of plasticine identical in size and weight. One of them is then rolled out into a long worm-like shape. Before the age of 7 the child is unable to conserve the quantity, the weight or the volume; after the age of 7 he will agree that the quantity is unchanged but he will not be certain about the weight or volume. Conservation of weight does not appear until 9 years of age, and that of volume even later, at about 11 years. The reason why the child of (say) 9 is able to explain that the quantity or the weight of the plasticine is not changed is that he is able to return to the original starting point, that is, he is able to state that the plasticine can be remade into its original shape without change in quantity or weight.

Operations have been referred to as actions which can be carried out in thought and which are reversible; but what cognitive acts would Piaget classify as operations? We have seen how a child's simple motor acts in the sensori-motor stage gradually become internalised. As they become more and more detached from overt behaviour and become internally represented, so they gradually become systematised. It is with this system that the child begins to organise the world around him into a more orderly place. He is able to co-ordinate these actions within his mind and to relate them to one another. As J. H. Flavell writes:

> 'These systems are equilibrated, organized affairs in the sense that one action may annul or otherwise compensate for another previously performed; two actions can combine to produce a third, and so on. That is to say, the system these actions form is truly a system with definite structural properties; it is something quite other than a simple concatenation or colligation of juxtaposed terms' (8; p. 165).

The system itself remains structured whereas the elements within it are fluid. Piaget explains the transition from intuitive thought to operational thought when the child becomes able to collect together these different relationships within a single structure or system. This development of grouping takes place at approximately the same state in many different areas of concept formation, so that a basic stock of concepts is acquired and these are organised into a coherent system. The most important areas are *classification, relations, number, time* and *space*.

(*a*) *Classification*

This is the concept of a class or the grouping of similar objects together. Piaget considers that a child achieves this only when he is able to define exactly the criteria which positively indicate the membership of a certain class known as *intension* or comprehension; and also to define all the objects which possess these criteria, known as *extension*. In a typical experiment (9) to study the composition of classes a child is shown a box containing twenty wooden beads, seventeen of which are brown and three are white. The child is then asked whether there are more brown beads in the box than wooden beads, or whether a necklace made from the brown beads would be longer or shorter than one made with wooden beads. The child's reply will depend upon his ability to handle the simple relation of the composition of classes. Thus, if B represents the wooden beads, A the brown beads, and C the white beads, then $B = A + C$; $A = B - C$; and $C = \mathrm{B} - A$. This indicates the ability to combine two classes, the white and the brown beads, to form a super-ordinate class of wooden beads ($B = A + C$); and also the ability to separate the wooden beads back into their original classes ($B - A = C$, and $B - C = A$). The child therefore, has to think of A and C as individual classes as well as being members of class B; also, in reverse, he has to remember B as a combination of classes A and C.

To illustrate this concept of classification it is interesting to note that children of about 6 years who readily agree that all dogs are animals will also firmly state that, if you took all the animals away, there would still be some dogs left. It is not until about the age of 7 years that the concept of a class is really achieved.

(*b*) *Relations*

At the same time as the child acquires the ability to combine and dissociate classes he also acquires the ability to arrange or serialise asymmetrical relations. This is in effect the ordering or arranging in a series objects which are unequal in size. If a child is given a number of wooden rods of unequal length he is able to arrange them in order of size not by mere trial and error or by comparing each rod individually with all other rods, but by selecting the smallest first, and then the smallest of those left and so on. This indicates that at about the age of 7 he is able to reason that since $A < B$, and $B < C$, therefore $A < C$. Furthermore, transitive relations are also understood permitting the child to deduce that if $A = B$, and $B = C$, then $A = C$. Also if he is able to order one set of objects according to their size, he is capable of doing the same with any other set of objects and of establishing a relationship between the elements of each set or their correspondence with one another. The importance of this will be seen when one considers the acquisition of number.

(*c*) *Number*

Children well below the age of 7 are able to learn how to count and even manipulate numbers; but this does not necessarily indicate an understanding of the concept of number, which is achieved only when the combination of classes and the ordering, or serialising, of asymmetrical relations are joined to form one complete operation. This combination of classifying and ordering is best illustrated from Piaget and Szeminska (9). Ten wooden dolls of the same thickness but varying considerably in lengths are presented to the children, and also ten walking-sticks of different lengths; the longest doll is twice as long as the shortest, while the sticks have much less variation. The children are told that the dolls are going for a walk and that each requires its own walking-stick; they are therefore asked to arrange the dolls and sticks so that each doll can easily find its personal stick.

It is not until the age of 7 years, or thereabouts, that a process of trial and error is eliminated and replaced by a systematic approach of selecting the shortest doll and placing it with the shortest stick, and so on. In fact, when asked to select the correct stick for (say) the sixth doll, the child will record that there are four dolls larger than the sixth, count down four from the largest stick (i.e. the tenth) and select out the fifth stick. A whole number is a collection of equal units as well as being an ordered series, and it is through this combination of its cardinal and ordinal relationships, or the co-ordination of the operation of classification and serialisation, that the operation of numbering is achieved. For Piaget an operation is a concept because it is a cognitive structure, and we therefore say that a particular child has achieved the concept of number. For Piaget, then, 'classes, relations and numbers thus form a psychologically and logically indivisible whole, in which each of the three terms completes the other two' (10; p. 144).

This fundamental grouping and the beginning of logical thinking are characteristic of the child of about 7 years, but his thinking becomes logical only when these different systems of operations combine to form an organised system of operations which obey certain laws. These laws are very similar to what mathematicians call *groups*; but Piaget refers to them as *groupings*, such as the following:

1. *Composition or combination* Two operations may combine to form a third or new element; for example, all rams and all ewes combine to form a new class, namely, all sheep.
2. *Reversibility* Whenever two operations are combined they can also be separated again. The new class, sheep, can be separated into the two original classes of rams and ewes. In mathematical terms this is the fact that subtraction implies the converse operation of addition, and multiplication implies the converse of division; for example $1 + 2 = 3$, but $3 - 2 = 1$; $6 \div 2 = 3$, but $3 \times 2 = 6$.
3. *Associativity* Operations can combine with each other in a variety of different ways; it does not matter in which order the combination occurs. Thus, 'all children + all male adults + all female adults = all human beings' is the same as 'all male adults + all female adults + all children = all human beings'; or in mathematical terms, $a + (b + c) = (b + c) + a$.
4. *Identity* Any operation combined with its converse is annulled; in mathematical terms $+2 - 2 = 0$. In thinking, a young child is unable to conserve his original data when attempting to solve a problem, whereas an adult can return to the original data/starting point without distorting it.
5. *Tautology* This operation has two distinct versions, one applicable to number and the other to logical relations. In number it is the property known as 'iteration', which states that any number combined with itself produces a new number; $3 + 3 = 6$, or $3 \times 3 = 9$. In logical relations a qualitative element or unit when repeated does not provide any further information. Repeating the information that 'A is larger than B', or '$A > B$', results in mere repetition of the information, whether in the form 'A is larger than B' or '$A > B$', and this is known as tautology.

The 'logico-arithmetical' groupings (as Piaget originally named them) of classification, serialisation and number are only part of a large body of operations which contains other operations concerned with time and space. Before we go on to consider these it should be noted that all these operations are understood or grasped only in concrete situations where the child is actively involved in the handling of the material objects. Neither the logico-arithmetical nor the spatio-temporal groupings can be applied by the child to purely verbal reasoning. In fact, when they are asked to reason with simple verbal propositions – the same propositions as they have handled in manipulating objects – they are unable to do so.

(*d*) *Time*

Piaget considers that time has two aspects which have to be coordinated before the concept of time is acquired. And as it is to be expected, these two aspects are operations which appear simultaneously with the child's ability to classify, seriate and handle number as discussed previously. The two aspects or operations are:

1. The ordering of events in succession, that is, before and after, on temporal relations,
2. The classifying of the intervals, called durations, between these successive events.

Prior, however, to the child's achievement in the ability to coordinate temporal relations with durations, he is able to state that if an object moves from *A* to *B* to *C*, in that order, and in the same direction, then it must have been at *A* before *B*, and at *B* before *C*, and that it will take more time to go from *A* to *C* than from *A* to *B*. Young children below the age of 6 also intuitively realise that, if two cars *X* and *Y* set off from the same place of departure and travel at the same speed and in the same direction, they will arrive at the same destination if they travel along a parallel course. If, however, one car travels faster and stops at a point further away, the child will not accept that they stopped at the same time. He argues that the longer route must take more time. In Fig. 28, *X* and *Y* arrive at *B* and *C* respectively at the same time; but the child concludes that the longer route to *C* must have taken longer.

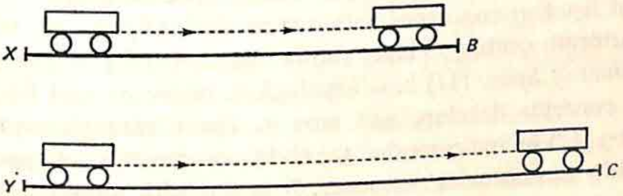

Figure 28

Closely linked with the concept of time is speed. A child's intuition of speed is based upon a temporal relation, that is, before and after; and on what Piaget calls 'spatial order', that is, behind and in front;

but it does not depend upon duration or the distance travelled. For example, if two cars are made invisible by passing through two tunnels they are judged to have moved at the same speed even though one tunnel is recognised as being appreciably longer than the other. When the tunnels are removed the child immediately realises that the car taking the longer route must be travelling at a greater speed. Only when the child has grasped the concept of speed does he become capable of a firm understanding of time, but time and speed are dependent upon each other for their development. As Piaget writes,

> 'At about the age of eight years relations of temporal order (before and after) are co-ordinated with duration (longer or shorter length of time) whereas the two systems of ideas were still independent at the intuitive level; as soon as they become joined in a single whole they engender the notion of time common to various movements (internal and external) at different velocities' (10; p. 144).

(*e*) *Space*

Piaget is concerned with space representation, not the mere perception of space; he considers that spatial concepts are achieved through activity or actions performed on objects. These actions become internalised and become operations which are reversible and are also part of an integrated operations system. The child develops through stages which appear to be in reverse of the historical discovery of space, or the sequence in which it is taught in schools. Scientific study of space began with the *Euclidean* system concerned with rigid shapes and angles. It was not until the seventeenth century that the development of *projective space* concerned with perspective arose, whilst the study of *topology* concerned with one particular figure only arose in the nineteenth century. Piaget shows experimentally in *The Child's Conception of Space* (11) how topological, projective and Euclidean spatial concepts develop, and also in *The Child's Conception of Geometry* (12) he indicates that the child's construction of space does not follow the historical sequence. It begins with topological space which is concerned with the relations of proximity, separation, order, enclosure and continuity, and the spatial relationships involved in a single figure.

From about the age of 6 these topological concepts are integrated into the more specific operations of projective space which involves the location of objects in space relative to one another, and Euclidean space which involves the location of objects in space with reference to three-dimensional axes and measurement. A child has to develop a concept of space before he can measure it in Euclidean terms and this concept is dependent upon or co-ordinated with the growth of logical thinking and involves a breaking away from an egocentric view of the physical world. Projective space begins psychologically when the child is able to appreciate or view an object no longer in isolation, and when it is thought of in relation to either the point of view of the subject (the person himself) or that of another object.

Euclidean space requires the concepts of measurement, horizontality and verticality which enable the child to construct frames of physical reference. These are acquired with the co-ordination of different viewpoints which are achieved in projective space. It is not until about the age of 11 that a child begins to acquire the ability to co-ordinate different perspectives, or to understand the measurement of length in three dimensions; and it is not until the age of 13 or 14 that the average child develops the ability to calculate volumes and proportions.

This period of concrete operational thought begins to change at about the age of 11. Up to this stage the child is capable of reasoning logically with concrete objects only, although he is able to co-ordinate these actions into a system which makes the world a more orderly place for him. He is able to construct concepts of a class, a series, number, time, space, weight, length and so on, but his thinking is still linked to objects and events which can be manipulated and are perceptible. It is when his thinking moves away from these tangible objects that the next stage in the development of his thinking occurs, and this stage is called the stage of *formal operations*.

THE FORMAL OPERATIONAL PERIOD (Eleven to Sixteen Years)

At about the age of 11 or 12, depending upon the social and cultural milieu of the child, formal thinking becomes possible. As we have seen, the child's thinking up to now has been tied to the actual physical reality of the objects he manipulates, but now these logical operations are transposed from reality to 'fantasy'. This does not mean that his thinking is unrealistic but that there is a gradual extension of these logical operations to thoughts which are capable of being expressed in words, language or some symbolic form. This is really another stage in the detachment of the child from his immediate perceptions. As a young baby of a few months he was first capable of conceiving an object only if he could see or touch it. After about six months the object became permanent even if not visible. By the end of two years the child became capable of representing to himself objects, events and people's actions which had occurred previously – a process we know as imitation. This extension of reality proceeded to the stage where the child of approximately 7 years was able to begin to detach himself from sensory perceptions and to reason logically about concrete objects.

Now in this final stage he becomes capable of thinking logically about possibilities, and not merely about reality. Perception of the object is no longer required and he manipulates statements and propositions in the same manner as he manipulated concrete objects at the previous stage. At the concrete level the child regards the field of the possible as a mere extension of the real; while at the formal level the real becomes merely an extension of the possible.

The child retains his previous attainment at the concrete level but is now capable of reasoning not simply with concrete propositions, but also with propositions which are verbal. Because of this he sets up a hypothesis and reasons or argues logically, using verbal statements. This ability to manipulate verbal propositions permits the development of hypothetical deductive procedures vital for the understanding of mathematics and science as well as for logic itself. He is able to manipulate relations between objects as well as to establish these relationships. Gradually the distance in time and space is increased and the child's thinking is no longer restricted either to the concepts he constructs from first-hand experience or to the stage where his logical thinking is applicable only to perceptible objects and events.

So, then, the child becomes capable of mentally manipulating propositions, of setting up a hypothesis, and of making deductions and of thus reasoning from propositions. Piaget, in conjunction with B. Inhelder (13), has devised a number of experiments to reveal the structure of these new thinking skills. The following examples will help to illustrate that the child at the stage of formal thinking is capable of logical justification and proof by the isolation and control of variables. In the first experiment, the 'Oscillation of the Pendulum', a child is presented with a length of string suspended from a hook and several weights which can be attached to the other end. The problem is to discover what determinates the rate of swing of the pendulum. These are four possibilities:

1. To vary the length of the string.
2. To vary the height from which the swing is started.
3. To vary the impetus or force imparted to start the swing.
4. To vary the weight of the pendulum itself.

At the Pre-Operational Stage there is little or no differentiation between the child's own action and that of the apparatus. He will tend to vary the impetus only. At the Concrete Operational Stage he is able to alter the length, height, impetus and weight, but he is generally unable to separate or control each factor individually. He judges the differences between the rate or frequency of the swing but does not separate the variables. In other words, he might decide to shorten the string but at the same time he will vary the height from which the swing is to commence.

It is not until he has reached the stage of Formal Thinking that he gradually develops the ability to vary one factor only at a time while holding all the others constant. He has to be able to reason if (say) the length of the string affects the time of oscillation, then the expected effect will appear only if all the other variables are held constant. This ability does not appear spontaneously at 11 or 12 years but gradually develops until, by about the age of 13 or 14, he becomes capable of isolating any of the variables present.

Another even more ingenious experiment is the 'Combination of Coloured and Colourless Chemical Bodies' (see Fig. 29).

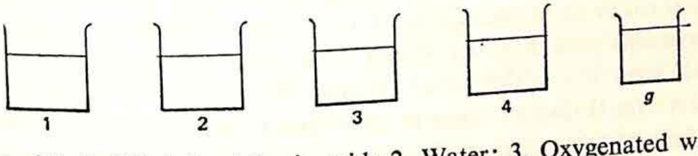

Figure 29: 1. Diluted sulphuric acid; 2. Water; 3. Oxygenated water; 4. Thiosulphate; g. Potassium iodide. These are all transparent liquids with no visible differences.

If g is added to a combination of 1 and 3 a yellow colour results; 2 is neutral and has no effect when added to this mixture, whereas 4 will bleach it. Thus, $1 + 3 + g$ = yellow colour; no change if 2 is added, but a reverse to the original if 4 is added.

In the experiment two containers are presented to the child. One contains $1 + 3$ and the other 2. The child watches as the experimenter adds several drops of g to each container; the container with $1 + 3$ turns yellow and the other remains unaffected. The child is then asked to reproduce the yellow colour using all or any of the five flasks. At the Concrete Level he usually tries in this manner:

(*a*) $4 + g$; $3 + g$; $1 + g$.
(*b*) $1 + 4 + g$; $2 + 3 + g$; and so on, but fails to cross over two sets of flasks, for example, $1 + 2$, $1 + 3$, $1 + 4$, $2 + 4$, $3 + 4$ etc.
(*c*) He attempts $1 + 4 + 2 + g$ and at this stage is usually very confused and, unable to retain mentally the operations required, gives up.

At the Formal Level such stages as the following occur:

(*a*) $1 + g$; $2 + g$; $3 + g$; $4 + g$.
(*b*) $1 + 2 + g$; $1 + 3 + g$ turns yellow, but the child queries whether there are other solutions and so continues.
(*c*) $1 + 4 + g$; $2 + 3 + g$; $2 + 4 + g$; $3 + 4 + g$, and discovers that the yellow colour is obtained only with $1 + 3 + g$.
(*d*) To test this he tries $4 + 1 + 3 + g$ and the colour disappears; therefore 4 cannot be water.
(*e*) When he tries $2 + 1 + 3 + g$ the colour remains; therefore 2 is water.

This line of experimentation and reasoning is continued in a systematic fashion until a conclusive deduction is made as to the correct solution; but such a sophisticated level of thinking does not usually occur until the age of 14 or 15 years. There are many other experiments described by Piaget who painstakingly worries at the logical structure of the actual process. He reveals that, generally, the child moves through a stage of unsystematic attempts at combination by trial and error at about the age of 7 to 9 years, to a stage where the beginnings of a combinational system appears at about the age of 11. Finally, at about 14 or 15 years a systematic combination approach develops, which is organised to establish and prove specifically defined hypotheses.

It is not intended to imply that once a child reaches this stage of development the level of his thinking remains always in the realm of the abstract. As we know ourselves, we often revert to the Concrete Level to solve problems or to achieve solutions by drawing diagrams and using models. The point to be stressed here is that there has been developed a level of thinking which is applicable not only to the single problem in hand but also to all problems and situations which do not necessarily appear related to one another.

Another interesting aspect of Piaget's work concerned with the adolescent is his reference to the fact that these cognitive structures are partially dependent upon the child's personal experience, which is acquired by his interaction with his environment, and also upon the nature of the social and cultural milieu within which he develops. The reason for this would appear to be that the adolescent is concerned with the future; he is concerned as to his future role, the occupations available to him, his marital prospects, and his status in society. All these factors have important feedback effects upon his reasoning ability. The adolescent is no longer tied to the present and immediate reality but is anxious and capable of planning the future and the remote. In this respect the curricula of secondary schools can assist the pupil considerably in his own personal development and in his adjustment within society.

What then has Piaget to offer education in a practical sense in schools? We have traced the cognitive development from reflexive to reflective thinking, and if we accept his theory at all then the one essential thread that runs through all his work is that action is necessary for the development of intelligence. At first these actions are merely reflexive and overt, but gradually the overt actions become internalised, covert, mobile and abstract at the Formal Operational stage. It is the learner's interaction with his environment which brings about the development of the concepts which enable the child to understand and organise a stable world. In general terms, Piaget's work would appear to have three important areas of application for education, which are enumerated by F. H. Hooper (14) as follows:

1. When a certain content or subject area should be taught.
2. What content or subject matter is most important.
3. How it may be best presented to the pupil.

Most modern infant, junior and middle schools provide for the children learning situations in which they actively handle the concrete materials. Playing about with water and sand, 5- and 6-year old boys and girls, may more quickly achieve true concepts of quantity, if not weight and volume, than those who sit in formal rows and never have the opportunity of weighing and measuring. If we accept that the Concrete Level is achieved at about 7 years and lasts until about 11 years, then it is probably a waste of time teaching ratio and proportion, area and volume in mathematics until this age is passed. In all subjects at this level the topics need to be related to the child's experience, or if this is not possible then concrete examples with visuals are essential. There would be little point in talking to junior children about the desert and camels if they had seen neither the original nor some pictorial representation of them.

How do we decide what material to present and when? It is necessary to know the children's background, their past experience and to have some indication of their individual cognitive development. The learning situations need to be slightly ahead of this development so that the children are motivated to resolve the conflict which this causes; but naturally the problem must not be so far beyond their cognitive development that as a result they are unable to achieve success. In all our subject disciplines, through which we present fresh concepts, children should engage in not only physical but also mental activity in order to ensure the understanding of co-ordination and relationships. An understanding and establishment of a system or set of relationships not only lessens the amount to be learnt but also facilitates generalisation, thus reducing the memorisation of meaningless rules. For example, if in mathematics the concept of continuous subtraction and addition were understood, then the relationship between multiplication and division would not be taught so often as a mere exercise in rote learning.

It is easy to find examples of this form of teaching in mathematics, but they can be found also in other subjects. Scientific understanding requires the ability to classify and seriate, as well as the competence to link systematically cause and effect. It may well be that there is an over-emphasis these days on innovation, and that children do not receive sufficient experience in one skill before they are taught others. For a concept to be thoroughly understood it must be presented in a variety of ways and in a variety of situations.

In history, the memorisation of past events does not involve advanced thinking skills, although the understanding of causal relationships clearly does. Obviously history involves a temporal progression, and some frame of reference must be established in order that the child may make effective mental excursions into the past. For this purpose there is a need to make use of some concrete materials, such as pictures and models, as well as to organise visits to historical places in order to establish these mental operations. Whether in history, science, mathematics, geography, literature, or religious education models and projects need to be employed, not because in educational terms they are the 'in thing' but because they form some of the concrete materials from which abstract ideas are built. In the realm of religious education, for example, a great deal of rethinking of syllabuses and methods has resulted from a consideration of the principles of Piagetian developmental theory; and it can no longer be taken for granted that the child is capable of receiving any 'religious truth' (in itself a highly controversial concept), provided it is sufficiently watered down (15).

To conclude it may be of some value briefly to summarise Piaget's theory concerning the stages in the child's cognitive development. Piaget sees the stage of Sensori-Motor Intelligence as the centre of all thought. Perception has an important role to play especially as at first the basic structure of the CNS has a more vital function than the social milieu. During this Sensori-Motor period there is practical satisfaction only and no understanding of a continuous whole, since the success of any action depends upon the co-ordination of successive perceptions and physical actions. To effect the transition from reflexive to reflective thinking it is necessary not only to increase the speed of action in order to establish a simultaneous whole, but also to see a development of the knowledge of results linked with the actions which brought them about, 'enabling search for solution to be combined with consciousness of its nature' (10).

There is also, of course, the increasing use of symbolic representation to extend time and space away from the immediate reality. To help bring about these changes there are intermediary structures which Piaget calls groupings which begin to develop at the end of the Sensori-Motor period at about two years. These 'groupings' enable thought to free itself from perceptual control and to be established on a new place where it is logical and operational, and where systems of classes and relations are established. This is the Formal Operational period which begins to develop at about the age of 11 or 12 but which is not finally completed until about 16 years.

In conclusion, it must be emphasised that although the normal developmental process is as we have indicated in this chapter, and that we expect children to reach the Formal Thinking stage during their secondary school life, not all children develop at the same rate.

It is very likely that these different stages will be found stradling both primary and secondary schools; and also that children will themselves be in different stages in different subject disciplines. It must be remembered that concepts develop from concrete experience, but that the more complex concepts are the more abstract they tend to be; and it is because of this that children fail to understand the work which has been set and so they begin to lose interest. In fact, they fail to learn.

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The time has passed when learning was identified purely as a process involving the ability to store and recall knowledge and facts, and the competence to produce them when required. These abilities still seriously concern the potential teacher and this book duly examines them, but the 'whys' and the 'hows' of learning and teaching are now considered as important as the implanting of facts for regurgitation at exam time.

Some children learn more quickly than others, some can remember facts more easily, and a teacher must ask several fundamental questions in order to understand the factors at work in this learning process. Where is knowledge stored? Why do we remember some facts and forget others? When are we learning new facts and when are we remembering and adapting knowledge to see it in a new light? To help to answer these and many other questions a number of learning situations, typical in most schools, are examined, the processes at work in the classrooms are examined, and then they are both related to different theories of learning.

The examination of a series of learning processes should not necessarily involve a choice between them, and a feature of Mr O'Connell's treatment is its lack of partiality towards any particular teaching method, although the teacher and student will draw their own conclusions.

The author has more than twenty-three years' experience as a head teacher and lecturer in education and this book reflects his interest in and concern for education.

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